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GEOGRAPHICAL HANDBOOK SERIES

FOR OFFICIAL USE ONLY

PACIFIC ISLANDS

VOLUME I

GENERAL SURVEY

August 1945

This volume was produced and printed for official purposes during the war 1939/45

PREFACE

IN 1915 a Geographical Section was formed in the Naval Intelligence Division of the Admiralty to write Geographical Handbooks on various parts of the world. The purpose of these handbooks was to supply, by scientific research and skilled arrangement, material for the discussion of naval, military, and political problems, as distinct from the examination of the problems themselves. Many distinguished collaborators assisted in their production, and by the end of 1918 upwards of fifty volumes had been produced in Handbook and Manual form, as well as numerous short-term geographical reports. The demand for these books increased rapidly with each new issue, and they acquired a high reputation for accuracy and impartiality. They are now to be found in Service Establishments and Embassies throughout the world, and in the early years after the last war were much used by the League of Nations.

The old Handbooks have been extensively used in the present war, and experience has disclosed both their value and their limitations. On the one hand they have proved, beyond all question, how greatly the work of the fighting services and of Government Departments is facilitated if countries of strategic or political importance are covered by handbooks which deal, in a convenient and easily digested form, with their geography, ethnology, administration, and resources. On the other hand, it has become apparent that something more is needed to meet present-day requirements. The old series does not cover many of the countries closely affected by the present war (e.g. Germany, France, Poland, Spain, Portugal, to name only a few); its books are somewhat uneven in quality, and they are inadequately equipped with maps, diagrams, and photographic illustrations.

The present series of Handbooks, while owing its inspiration largely to the former series, is in no sense an attempt to revise or re-edit that series. It is an entirely new set of books, produced in the Naval Intelligence Division by trained geographers drawn largely from the Universities, and working at sub-centres established at Oxford and Cambridge. The books follow, in general, a uniform scheme, though minor modifications will be found in particular cases; and they are illustrated by numerous maps and photographs.

The purpose of the books is primarily naval. They are designed first to provide, for the use of Commanding Officers, information in a

comprehensive and convenient form about countries which they may be called upon to visit, not only in war but in peace-time; secondly, to maintain the high standard of education in the Navy and, by supplying officers with material for lectures to naval personnel ashore and afloat, to ensure for all ranks that visits to a new country shall be both interesting and profitable.

Their contents are, however, by no means confined to matters of purely naval interest. For many purposes (e.g. history, administration, resources, communications, etc.) countries must necessarily be treated as a whole, and no attempt is made to limit their treatment exclusively to coastal zones. It is hoped therefore that the Army, the Royal Air Force, and other Government Departments (many of whom have given great assistance in the production of the series) will find these Handbooks even more valuable than their predecessors proved to be both during and after the last war.

J. H. GODFREY

Director of Naval Intelligence

1942

The foregoing preface has appeared from the beginning of this series of Geographical Handbooks. It describes so effectively their origin and purpose that I have decided to retain it in its original form.

This volume has been prepared for the Naval Intelligence Division at the Cambridge sub-centre (General Editor, Dr H. C. Darby). It has been mainly written by Dr J. W. Davidson, Dr Margaret Davies, Dr Raymond Firth, Dr L. Hawkes and Dr P. W. Richards, with contributions from Mr A. E. P. Collins, Mr Adrian Digby, Dr J. P. Harding, Professor A. A. Miller, and Dr Charles Wilcocks. The maps and diagrams have been drawn mainly by Mr A. O. Cole, Miss K. S. A. Froggatt, Miss F. Hands, Miss M. Hart, and Mrs Gwen Raverat. The volume has been edited by Dr Raymond Firth and Dr J. W. Davidson.

E. G. N. RUSHBROOKE

Director of Naval Intelligence

August 1945

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INTRODUCTION

Significance and Status of the Pacific Islands: Plan of the Handbook

SIGNIFICANCE AND STATUS OF THE PACIFIC ISLANDS

Though the Pacific ocean is so vast, the land area of the islands which it contains is relatively small. The total is about 400,000 sq. miles, and of this roughly 90% is comprised by New Guinea. The population of the islands is only about $2\frac{1}{2}$ millions. Only a few islands are known to possess resources of much importance in the world economy. In recent years, however, the importance of some islands for the development of air communications has become evident, and students of political and military matters have been made aware of the strategic significance of the region as a whole to the powerful states round the borders of the Pacific basin. This significance was forcibly driven home after the outbreak of war with Japan in 1941. The names of many Pacific islands are now generally known, and something of their importance is widely understood. The rapid changes brought about by the war, however, make more difficult the presentation of an exact picture of the geography of the region. These changes, together with the basic factors of physical, social and political diversity, make it necessary for a Handbook on the Pacific islands to follow a somewhat different treatment from that adopted in dealing with a compact geographical and political entity, such as a European country.

Conditions of life in the Pacific islands depend very largely on the oceanic environment. Some account of the Pacific ocean—its size and form, its climate, its fauna, etc.—is therefore necessary to explain the characteristics of the islands. Vegetation is largely influenced in the same ways—some plants have been spread through the agency of ocean currents; others have been introduced by human travellers; practically all the plant life of the coral islands is affected by the surrounding seas. The history of the islands, especially in its earliest phases, is largely one of sea travel—of voyages of discovery and exploration, of trade between islands and with the world beyond, of the transport of labour from one island group to another or to the neighbouring continents, of the visits of mission-

aries to isolated island communities. Economically, whaling and the search for pearls and other products of the reefs and lagoons have been important factors in the development of the islands, and fishing is still one of the main means of livelihood of a large part of the native population. Most of the towns in the islands owe their importance largely to the fact that they are also ports; and, despite recent and prospective developments in air communication, the life of most island communities will remain dependent on shipping for a long time to come.

Politically, the Pacific island territories are all in some degree dependencies of more powerful states outside the island region. These political linkages do not always follow the natural geographical groupings. Thus, United States territory is to be found (in Samoa) in the middle of a ring of British territory, or (in Guam) surrounded by islands formerly held by the Japanese under mandate from the League of Nations; the French colony of New Caledonia is adjacent to Australia, but separated by half the width of the Pacific from French possessions in the Eastern Pacific; and, again, some groups of islands are divided between separate administrations or administered jointly by two Powers as a condominium. The political status of the more important territories (as in 1939) is shown in the following Table:

Pacific Islands: Political Status †

Controlling Power	Area	Status
Britain		
(i) United Kingdom	Fiji (including dependency of Rotuma)	Colony
	Tonga	Protected State
	Solomon islands (excluding Bougainville and islands northward)	Protectorate
	Gilbert and Ellice islands, Ocean island, and some small central Pacific dependencies	Colony
	Pitcairn group	Colony
(ii) Australia	Papua	Territory
	North-east New Guinea (including northern Solomon islands	Mandated Territory
	Norfolk island	Territory
	Lord Howe island	Part of the State of New South Wales

Pacific Islands: Political Status—continued

Controlling Power	Area	Status
(iii) New Zealand	Western Samoa	Mandated Territory
	Cook islands	Territory
	Niue	Territory
	Tokelau group	Territory
	Kermadec islands	Territory
(iv) United Kingdom, Australia and New Zealand	Nauru	Mandated Territory (administered by Australia)
Britain (United Kingdom) and France	New Hebrides	Condominium
Britain (United Kingdom) and United States	Canton and Enderbury	Condominium
France	New Caledonia and Loyalty islands	Colony
	Uvea (Wallis island) and Futuna	Protectorate
	French Establishments in Oceania (Society islands, Tuamotu archipelago, Mangareva group, Austral islands and Marquesas)	Colony
United States of America	Hawaiian islands	Territory
	American Samoa	Dependency under naval jurisdiction
	Guam	Dependency under naval jurisdiction
Netherlands	Dutch New Guinea	Part of the Outer Provinces of the Netherlands East Indies
Japan	Marianas, Caroline islands, and Marshall islands	Mandated Territory
	Bonin islands	Part of the Prefecture of Tokyo

† The position regarding sovereignty in the Pacific immediately prior to the war of 1914–18 is shown in Fig. 95; administrative areas in the Eastern and Western Pacific respectively, as at the outbreak of war in 1939, are shown in vol. II, Fig. 2 and vol. III, Fig. 2.

PLAN OF THE HANDBOOK

Though the oceanic setting gives to the Pacific islands many common characteristics, physical and social, the region is so large and many of the islands are so isolated that great diversity remains. In treating the region as a unit, only very broad generalization is possible, and much that is of primary importance in particular areas has perforce to be omitted or passed over very briefly. The Handbook is therefore divided into the present introductory volume, which gives a general survey of the Pacific ocean and of the islands as a whole, and three

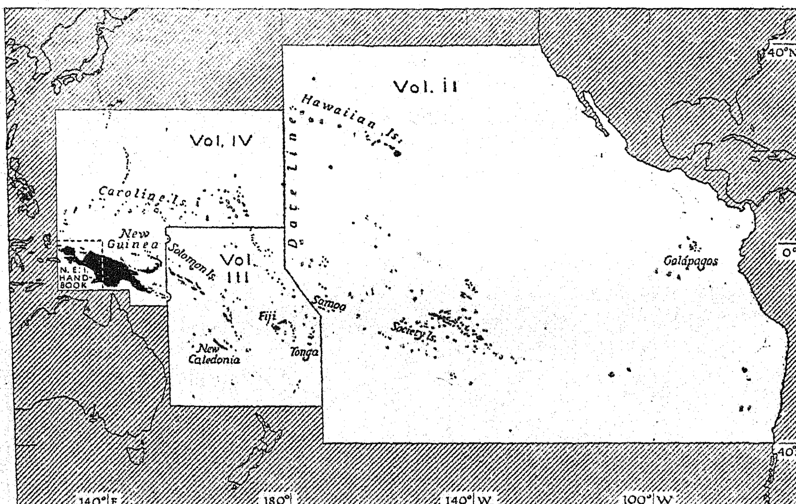


Fig. 1. Key map to the Handbook
The unshaded areas contain the islands described in volumes II, III and IV.

regional volumes, which describe the characteristics of each group or island in turn. Volume II covers the islands of the Eastern Pacific; volumes III and IV deal with those of the Western Pacific. (The area covered by each of the regional volumes is indicated in Fig. 1.) For the description of each group the same system of headings is followed as far as possible; and, for the major areas, the general review is followed by a description of the physical characteristics and social and economic conditions of each island individually. A bibliographical note is given for each group of islands.

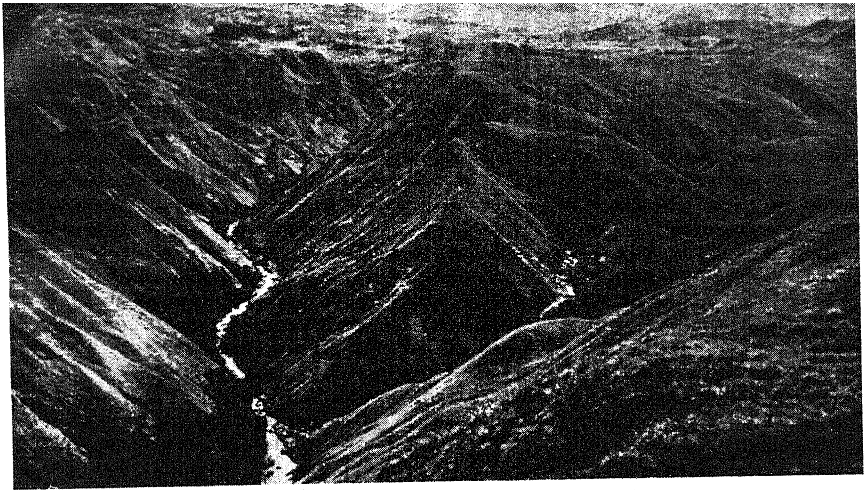


Plate 1. The Dunantina river, New Guinea
Showing erosion forms on the southern slopes of the Bismarck range (part of the Archaean core of New Guinea). There are few high outstanding peaks owing to levelling of the core prior to uplift. Recent erosion has produced deep valleys.

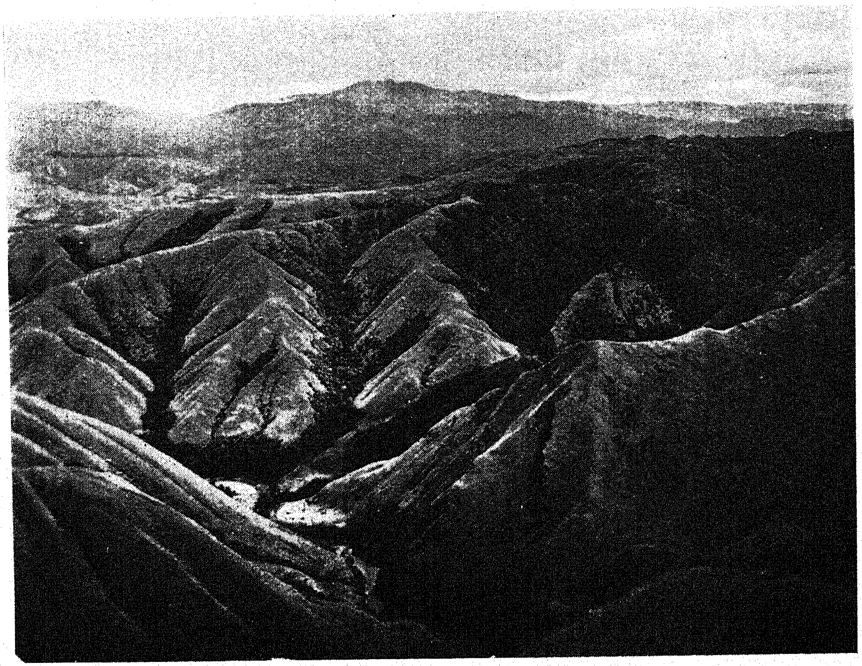


Plate 2. The Watut-Tiviri watershed, New Guinea
This view in the central highlands shows recent erosion of the uplifted core. At this elevation forests are confined to valley bottoms and most of the surface is under grass.

Plate 3. The eastern barrier reef, Mangareva
A view looking north at high tide, showing the sea breaking against the steep coral beach. Two small reef islets can just be seen on the horizon.

Plate 4. Tarawa, Gilbert islands
In the foreground is Betio (Bititu) island, on which

Chapter II

GEOLOGY AND PHYSICAL STRUCTURE

General Features : Types of Rocks : Age and Origin of the Pacific : Active and Extinct Volcanoes : Earthquakes : Coral Reefs : The Sculpturing of Volcanic Islands : Deposits on the Floor of the Pacific : Bibliographical Note

The Pacific ocean is bounded by fold mountains which show great instability, and earth movements and vulcanism are features of many of its 20,000 islands. A large number of these islands have been built up by corals, and, here again, there are frequent changes in the details of the landscape. East of 150° W depths are relatively more uniform and island groups are infrequent. The majority of the islands and the great ocean deeps lie west of this meridian. The island arcs are roughly concentric to Australia, and the inner islands share some of its continental rocks (Plates 1 – 2), but these become rarer in the more easterly arcs. Younger folded rocks are also well developed in all these arcs. Coral reefs are frequent and, as one passes towards the centre of the ocean, coral rock predominates on the surface of the islands (Plate 3). Many are wholly of coral (Fig.2). Melanesia, Micronesia and most of Polynesia are set in the west of a great ocean, the greatest unit of the hydrosphere. The majority of the Pacific islands lie in a sector of the Pacific which in area is roughly equal to the Indian ocean, and to north and east lie vast stretches of ocean, for the most part, like the North and South Atlantic, empty of island groups.

GENERAL FEATURES

The Pacific ocean has been variously defined. Two main usages of the term may be noted. It may be regarded *either* as the area bounded by the continents of North and South America, Antarctica, Australia, and Asia, and marked off from adjoining seas by Bering strait (36 miles wide) in the north and the meridians of South-east cape (Tasmania), and cape Horn in the south, *or* this area restricted by the exclusion of the bordering Bering, Okhotsk, Japan, Yellow and East China seas, and of Bass strait, and of the Californian gulf. The term 'Pacific basin' as used by geologists is a still further restricted area (p. 14).

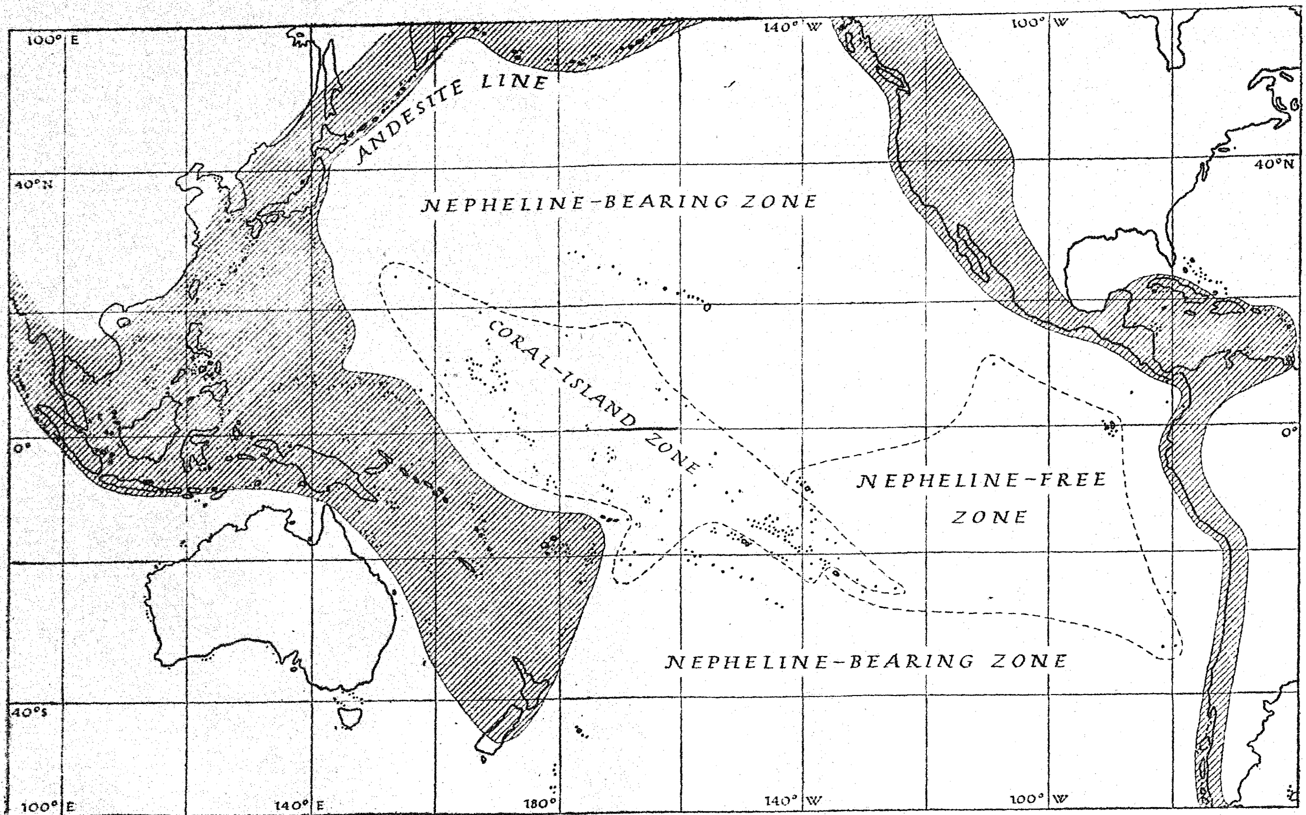


Fig. 2. Distribution of rock types in the Pacific

The Pacific basin is enclosed by the andesite line; the andesite zone is shaded. Nepheline is a rock-forming mineral found in hexagonal crystals. The nepheline zone is a division which includes those volcanic islands in which nepheline-bearing rocks predominate or are well represented. The islands of the nepheline zone are usually in linear groupings. Based on L. J. Chubb, 'The Structure of the Pacific Basin', *Geological Magazine*, vol. LXXI, p. 290 (London, 1934).

Comparative size

The following comparative figures are of interest:

Areas (in millions of sq. miles):	
Earth	197.0
Total lands	57.5
Total seas	139.5
Pacific (with bordering seas)	69.4
Pacific (without bordering seas	63.8
Atlantic (without bordering seas)	31.8
Average Depths (in fathoms):	
Total seas	2,078
Pacific (with bordering seas)	2,251
Pacific (without bordering seas)	2,341
Atlantic (without bordering seas)	2,147
Volumes (in millions of cubic miles):	
Total seas	329
Pacific (with bordering seas)	174
Pacific (without bordering seas)	170
Atlantic (without bordering seas)	78

Thus the area of the Pacific with its bordering seas is about one-third that of the earth, one-half that of the oceans, and one-fifth greater than that of the land. The Pacific ocean has a cubic content seven times as great as the bulk of all the land over sea-level. The form of the area can be realized only by examining a globe. The distance from Bering strait southwards to cape Adare, Antarctica, is approximately 9,320 miles. The point on the earth most distant from land is at 47° 30′ S, 118° 30′ W, and lies 1,560 miles from the nearest coasts of South America, Peter I island in Antarctica, and Ducie island. The distance from shore to shore across the Pacific in latitude 15° N is almost twice as great as that across the Atlantic ocean along the same parallel. While there is a relatively constricted area between the northern and southern Atlantic basins (the distance from Brazil to Liberia is roughly 1,700 miles), there is no such narrowing in the Pacific ocean. Profound differences in water circulation and in modern communications arise from this major contrast between the two oceans, and also from the fact that the Pacific, unlike the Atlantic, is shut off from the Arctic ocean.

The Ocean Floor

Despite advances in echo-sounding technique whereby depth is rapidly found by noting the time of travel of sound waves to the bottom of the sea and back, only the broad features of the form of the Pacific floor are known. The question as to whether the

floor has irregularities at all comparable with those of the land surfaces will not be resolved until sounding methods have been further developed. The most favoured opinion among geologists is that the greater part of the Pacific floor has lain below the sea for geological ages—perhaps since the time of the birth of the hydrosphere—and that therefore the varied forms of relief developed by erosion of the lands are not to be expected there. If this is so, the relief must be due either to differential movements of the sub-oceanic earth's crust or to the accumulation of materials from submarine volcanoes.

The floor is covered by an unknown thickness of soft fine-grained marine deposits (p. 52). As at present known it is generally level, with elongate gentle rises and depressions with straight-line or slightly curving trends. Many of the rises support lines of islands. In addition, there are the elongate 'great deeps', a characteristic feature of great stretches of the border of the Pacific. These deeps are commonly called 'troughs' or 'trenches'—terms which may give a false idea of depressions in which the sides do not attain slopes of more than 7° and are commonly even more gentle. It must be borne in mind that in drawing sections across ocean floors it is usual greatly to exaggerate the vertical scale, with a consequent unnatural steepening of slopes; the sections of Figs. 3–5 will illus-

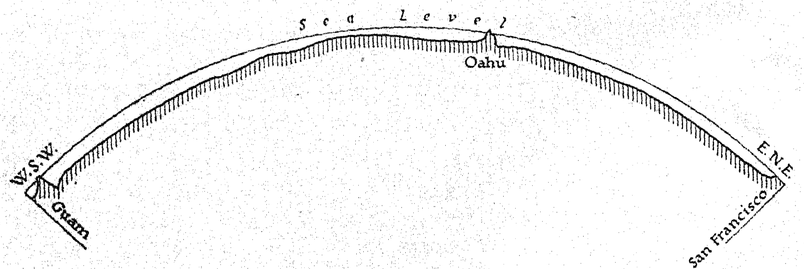


Fig. 3. Section across the Pacific basin

This section extends over a quarter of the earth's circumference. The vertical scale is exaggerated 30 times. Based on F. A. V. Meinesz, *Gravity Expeditions at Sea*, vol. II, plate I (Delft, 1934).

trate this point. The deeps are situated not in the middle of the ocean, but either near to and parallel with the continental borders or along lines of islands marking the borders of the geologist's 'Pacific basin' (Fig. 7). Fig. 6 shows that many of the deeps are arcuate in plan with high land on one side—usually on their concave side; they are accordingly known as 'fore-deeps,'' i.e., the ocean

Plate 5. Model of the north Pacific floor

This model shows the submarine ridges and deeps ; the lighting is from the west side. It may usefully be compared with the folding map at the end of the volume.

Plate 6. Columnar basalt, Ponape
Basalt is well developed in the Jokaj cliff in the north-central part of Ponape.

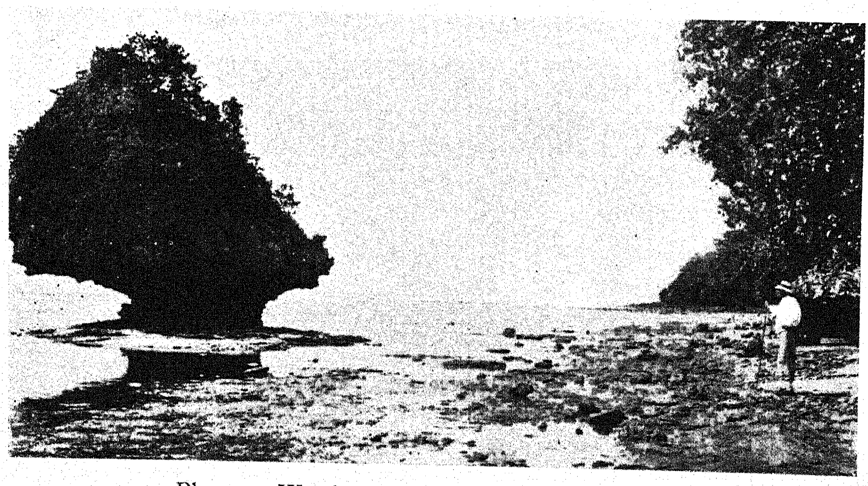


Plate 7. Weathered limestone block, Mango, Fiji
Note the way in which this limestone boulder has been undercut by the waves.

hollows in front of the land elevations. The marginal lands of the Pacific are all mountainous and the deeps commonly lie closest to the mountains where they are highest. Great earth movements have occurred in these marginal areas. The maximum ocean depth recorded, 5,902 fathoms (6·7 miles), is from the Planet deep off the Philippines; this depth is about half the amount of the earth's radial polar flattening. The south-eastern sector of the Pacific is

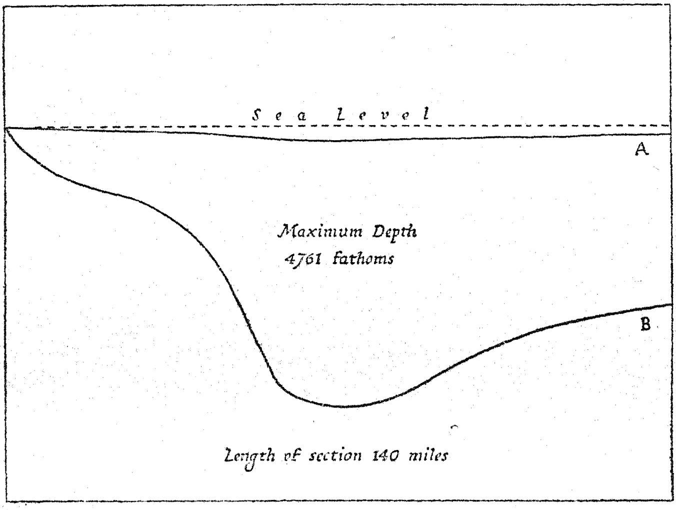


Fig. 4. Section across the Tonga deep

The true scale is shown by A. In B the vertical scale has been exaggerated 20 times. Based on various sources.

revealed on Fig. 6 as one of rather less than average depth. There are four relatively small deeps parallel to the Peruvian and Chilean coasts in this sector, viz.:—the Atacama trench, 4,175 fathoms; the deep lying off the angle of the coast where the Peruvian and Chilean coasts adjoin, 3,755 fathoms; that lying off Callao, 3,209 fathoms; and the deep which lies off Valparaiso, 3,099 fathoms. The three deepest troughs lie off coasts which slope steeply up to the high Andes. The south-eastern sector has few islands. In the Western Pacific there are many chains of islands, and off them on their eastern margins lie the fore-deeps. In addition to the great trench sounded by the *Emden* off the Philippines are deeps lying east of the Palau islands and east of Yap. The maximum sounding from the deep lying south-east of Guam and the Marianas is 5,788

fathoms. Off New Guinea and the Solomons the Bougainville trench is 5,490 fathoms deep, while the deep off New Caledonia reaches 4,139 fathoms. The long Kermadec-Tonga deep which stretches from 36° S northward to 16° S reaches 5,639 fathoms (Fig. 6).

The model (Plate 5) of part of the north Pacific floor is based on over 17,000 soundings made by the U.S.S. *Ramapo* between lat. 10° N and lat. 50° N. It gives a valuable picture of the positions and trends

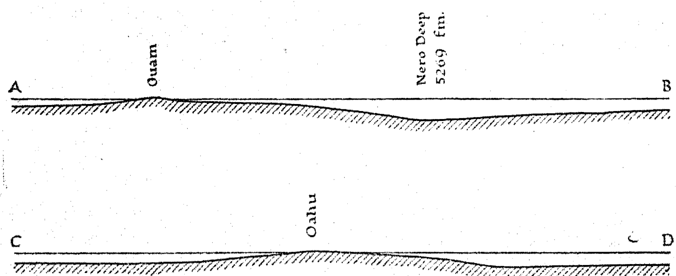


Fig. 5. True-scale sections across the Pacific ocean

These sections run approximately from west to east. A-B is across the Nero deep, and covers a distance of 360 miles. C-D, through Oahu, represents a distance of 190 miles. Based on F. A. V. Meinesz, *Gravity Expeditions at Sea*, vol. II, plate I (Delft, 1934).

of the major rises and hollows, but a false impression of the magnitudes of these departures from the general level, as the vertical scale of the model is exaggerated 50 times. The Hawaiian 'swell'—a gentle rise 600 miles wide and 1,900 miles long—trends NNW-SSE (Fig. 5, Section C-D). Shorter NE-SW rises cross its main axis and there is a suggestion that volcanic activity is more intense at the intersections. In the south Pacific is the Albatross plateau, an under-sea area of continental dimensions less than 2,500 fathoms below the surface. Its few islands do not lie along lines but are isolated volcanic piles.

The areas of the Pacific floor lying between various depths can be found from Fig. 7, which shows that, compared with the other oceans, the average depth is greater and the descent from the coasts to the general ocean floor steeper.

TYPES OF ROCKS

No samples have been obtained of the solid rocks beneath the universal cover of soft deposits (oozes, corals, etc.) on the ocean floor. Of the solid outer part of the earth 71 % is at present a 'terra incog-

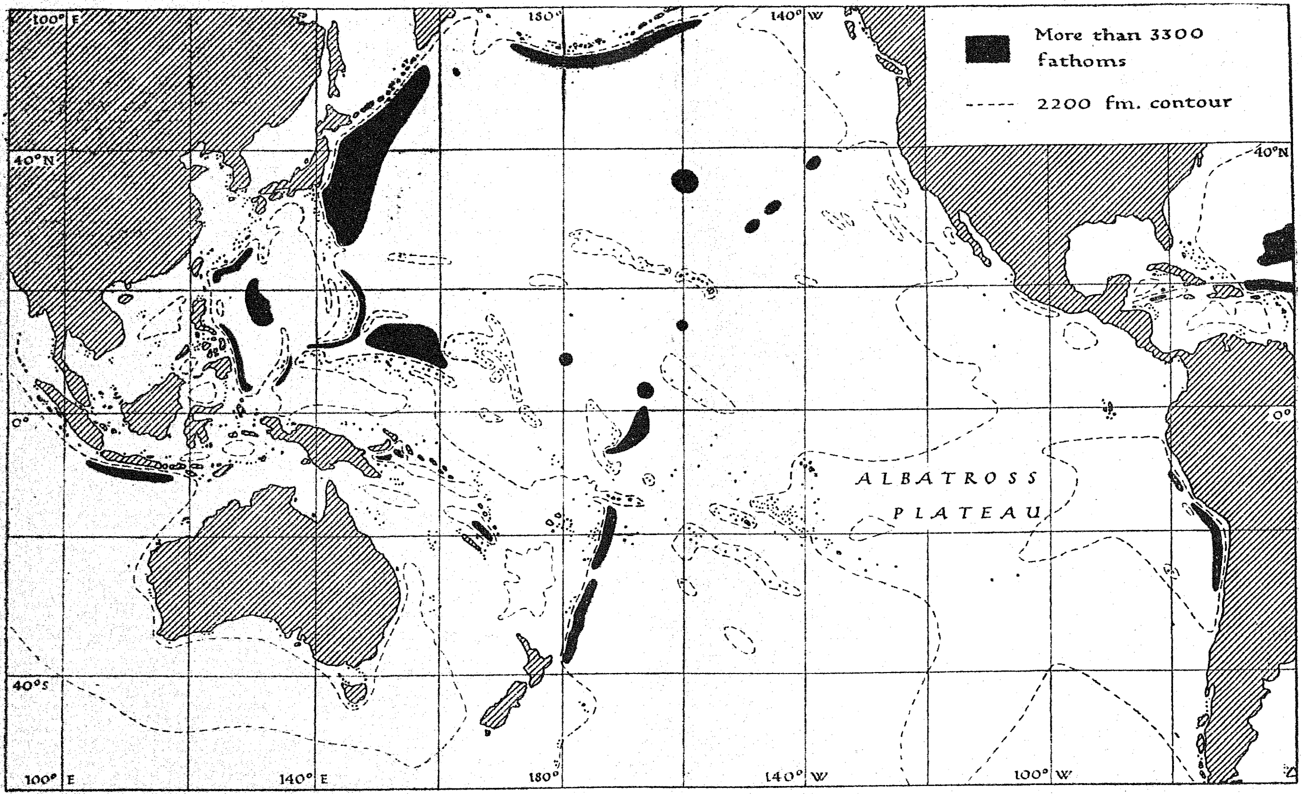


Fig. 6. Pacific ocean depths

The pecked line is the 4,000-metre contour. Areas where the depth exceeds 6,000 metres are shown in black. Based on E. J. Chubb, 'The Structure of the Pacific Basin', *Geological Magazine*, vol. LXXI, p. 291 (London, 1934).

nita' to the geologist and it is one of his dreams that one day means, scientific and financial, will be found to explore this field. At present we have to rely on indirect evidence. The rate of travel of earthquake waves through the rocks of the floor and the force

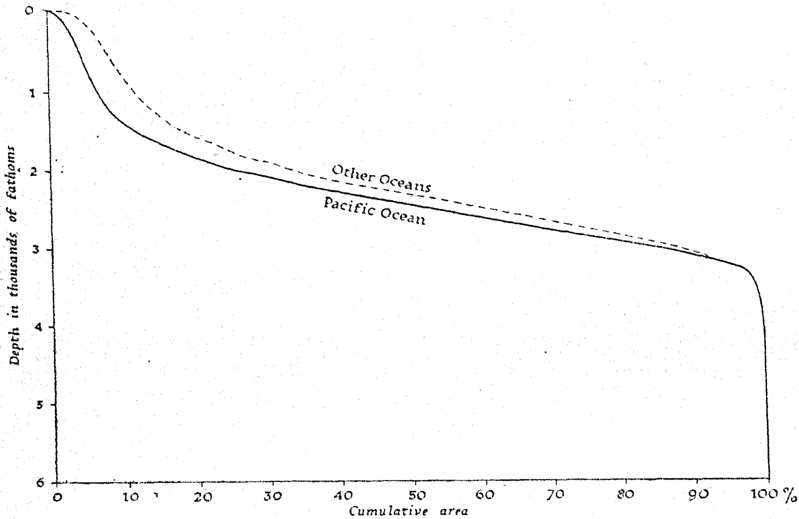


Fig. 7. Relation of depth to area in the Pacific and other oceans

The purpose of this curve is to demonstrate the percentage of area between any two depths by the usual method of co-ordinates. Seas bordering on the Pacific are excluded. Based on various sources.

of their gravitational attraction prove that they are rigid and heavy, as compared with the lighter rocks forming the continents. In agreement with this the igneous rocks of the Pacific islands, which have been formed from material forced to the surface in the fluid state, are for the most part relatively heavy. It should be realised that the earth is solid to a depth of over 1,800 miles, and that the volcanoes derive their materials from liquid pockets which at times and in restricted regions are formed within the crust.

Igneous Rocks

In overwhelming proportion, the rocks of the Pacific islands are volcanic, i.e., formed by the cooling and solidification of hot rock liquid which has been forced to the surface. (The student of Pacific geological literature must be warned that observations reported at one time have, in some cases, been contradicted later.) Large

continuous masses are known as lavas. Very commonly there is explosive activity due to the expansion of dissolved gases which takes place when the pressure on the liquid is reduced by its rise to the surface. This results in the dispersal of fragments which vary in size from bombs (volcanic rock masses one foot or more in diameter) through lapilli and scoriae to fine ash or tuff. A deposit formed of a mixture of variously-sized fragments is called an agglomerate.

The geologist classifies rocks according to their chemical and mineralogical composition and he has coined a bewildering number of forbidding names for them. For the precise connotation of these names reference must be made to a petrographical dictionary. To understand what follows it will suffice to know a few comprehensive terms and to realize that the amount of silica varies in the different rocks, which may accordingly be placed in a series from basic rocks poor in silica to acid rocks rich in silica. The main rock types with their approximate silica-content ranges are:

Oceanites, etc.	37–45%	silica
Basalts	43–50%	,,
Andesites	47–58%	,,
Trachytes	56–66%	,,
Rhyolites and obsidians	68–72%	,,

In general, with increasing acidity the colour of the rocks passes from dark to light, but glassy rocks (obsidians) are black, unless they are very vesicular (pumice). Also, in general, with increasing acidity the specific gravity decreases from about 3·2 to about 2·4. If the rock liquid solidifies beneath the surface it cools more slowly and the crystals are larger. These coarser-grained 'plutonic' rocks are named picrite (which is oceanitic in composition), gabbro (basaltic), diorite (andesitic), syenite (trachytic), and granite (rhyolitic). Plate 6 shows a mass of columnar basalt.

Other Rocks

These include sandstones, mudstones, and limestones (Plate 7 shows a shore formation), many with a certain mixture of volcanic material and many changed (metamorphosed) by heat and pressure into quartzites, slates and marbles. Extreme metamorphism has resulted in the production of schists and gneisses—hard, finely banded rocks. The economically important phosphate rock is described in a separate section.

It may be pointed out here that continents have a base of light, coarse-grained rocks such as granite and gneiss, together with

sedimentary rocks, the older series of which are commonly highly disturbed, folded and metamorphosed.

The Inner Basin and its Islands

On a basis of rock composition the geologist separates an inner Pacific—the Pacific basin proper—from an outer one. The line of demarcation is known as the andesite line (Fig. 2) because, while basalts predominate within it, andesites are common in the islands and continental borders between it and the bounding land masses. The andesite zone lies, then, on the landward side of the Pacific basin of the geologist, and includes not only the relatively recently folded mountains of the continental borders—e.g., of the Rocky Mountain complex—but also, around the northern and western margins, many large and smaller island groups. The Philippines, Japan, and most of New Zealand lie within the andesite zone, and so do the island groups included in Melanesia, and the Carolines and Fiji. Within the Pacific basin proper the rocks of the islands are overwhelmingly basic—oceanites and basalts with very subordinate amounts of trachyte and more acid rocks. Rhyolite and obsidian are found only in Easter island and Tutuila. Erosion of extinct volcanic cones has exposed small bodies of gabbro and syenite, but no granite has been found. The islands of the coral zone (Fig. 2) are partly or wholly composed of coralline and other limestones which, however, are but cappings laid down on the tops of volcanoes.

Islands Outside the Basin

The rocks of most of the islands outside the inner basin are volcanic; but 'continental' rocks—i.e., granites and gneiss and other highly metamorphosed rocks—are found in the following island arcs: the Aleutian, Japanese, Ryukyu, Philippines, New Guinea-New Caledonia; also in Yap (Carolines), Vela (Truk), New Ireland, the Solomon islands, the Fiji-Tonga group, New Zealand, and the Kermadecs (Fig. 2). In addition, the widespread occurrence of andesites—rocks which are common in the borders of the Americas—is taken to be a sign of the presence of 'continental' rocks.

As an example of the kind of evidence which such 'continental' islands afford, Viti Levu (Fiji) may be cited. The oldest rocks are a series of volcanics with some quartzose sediments folded and metamorphosed and (apparently) intruded by granite, diorite, and gabbro. The precise age of these rocks is unknown but they are pre-Tertiary. (The following general Table is given for reference.)

Table of the Main Geological Periods

Era	*Period*
Quaternary	Recent Pleistocene
Kainozoic (*Tertiary*)	Pliocene Miocene Oligocene Eocene
Mesozoic (*Secondary*)	Cretaceous Jurassic Triassic
Palaeozoic (*Primary*)	Permian Carboniferous Devonian Silurian Ordovician Cambrian
	Pre-Cambrian or Archaean

These rocks are exposed in widely scattered regions in Viti Levu and they presumably form the base of the whole of it. They indicate an early period of mountain building followed by prolonged erosion which removed vast thicknesses of rock. Afterwards, in Tertiary times the younger rocks were laid down. These latter consist of about 4,000 ft. of volcanic rocks together with marine limestones.

It is clear that prior to the Tertiary period Viti Levu was a larger land area and the same conclusion applies for the other 'continental' islands. Some geologists advocate the former existence in the south-west Pacific of a large Melanesian continent extending east and south from Australia. This area is now largely deep sea and Fig. 6 demonstrates the scantiness of available evidence. The 'continental' islands were certainly larger in some part of pre-Tertiary times, but the extent of the former land area remains highly problematical. This matter is further discussed in a following section.

Rocks and Ores of Economic Value

As a whole, the Pacific islands are not rich in minerals of com mercial importance, though there are some important sources in

the Western Pacific, and phosphate occurs in a number of islands in both the Western and Eastern Pacific.

Phosphate

Phosphate is the only rock of economic importance in the limestone islands. It is derived from guano, the droppings of birds (though according to one theory some of the deposits may have been derived from marine sources). The chief sea-fowl forming rookeries are the sooty tern, the man-of-war hawk or frigate bird, the mutton bird (a petrel), the pelican, the bosun bird, and the gannet. These birds in the Pacific generally occupy low islands, some not more than 10 ft. high, and long before the land comes within the range of vision its position can be determined by the clouds of birds seen hovering over it. (Many of the islands on which phosphate occurs, however, have now long ceased to be bird rookeries.)

The guano is rich in soluble di-basic phosphate which is leached out by rain and spray, and the solutions act upon the limestone rock beneath, forming the less soluble tri-basic phosphate. There are intermediate stages between guano and phosphate rock, and some deposits are called guano-phosphate. Guano has been worked on islands such as Clipperton, Malden, Howland, Baker and Starbuck. Guano-phosphate is worked on islands such as Surprise, Fabre and Le Leizour of the Huon group north of New Caledonia, the Chesterfield group west of New Caledonia, and Walpole, south-east of New Caledonia. Rock phosphate is mined in Saipan and Rota (Marianas), in Peleliu, Tobi, Sonsorol and Angaur (Palau), in Ebon (Marshall islands), and in Makatea, Ocean island and Nauru. (For estimated reserves of the last three islands see vol. II, p. 208.) There are a few other minor sources also, but all likely islands in the Pacific have been examined (often two or three times by different parties searching for phosphate), but without success. Apparently the only undiscovered phosphate to be hoped for is a little recent guano deposited on islands unfrequented by man.

The discovery of phosphate on Nauru was unexpected. In 1897 an unusual-looking piece of rock was brought from Nauru to Sydney, where for three years it was used at company offices to keep a door open. It was eventually tested and found to be rock phosphate. Nauru and the neighbouring Ocean island contain the richest deposits of rock phosphate now known in the world; in the years immediately before the war they yielded about a million tons of phosphate per annum. (For further details of exports see vol. III,

pp. 351–4.) The rock occurs in the two islands at the surface under a veneer of guano-phosphate, and occupies the space between innumerable pinnacles of limestone which, after the phosphate has been dug, present a fantastically irregular landscape (vol. III, Plate 49). Phosphate is worked from between the pinnacles to a depth of 30 ft. or so at Nauru, and to as much as 65 ft. on Ocean island. There is still phosphate underfoot, but it does not pay to dig when the space between the broadening pinnacles becomes very narrow. The percentage of tri-basic phosphate is not only high, but fairly uniform; shipments average 85 and 88% of tri-basic phosphate of lime.

Nickel and Chrome

The most important sources of nickel and chrome are in New Caledonia, which, though its contribution to world production is not large, occupied before the war second place among nickel producers and about seventh place among producers of chrome. Both the nickel and the chrome in New Caledonia occur in the serpentine rocks. The nickel is in the form of garnierite, a compound of nickel and magnesium silicate, which occurs very sporadically in small discontinuous veins and pockets. The chrome occurs in the form of chromite, which is an iron chromium oxide, with certain impurities also present; it varies in colour from dark brown to black and is widely distributed, often concentrated in deposits near the surface left after the surrounding rock has been eroded away.

Gold and Other Minerals

Gold is obtained from New Guinea and Fiji, and has also been discovered in Guadalcanal in the Solomon islands, though production was interrupted by the outbreak of war. The metal also occurs in New Caledonia, in the alluvial deposits of the Diahot valley and in quartz veins in the old metamorphic rocks in the mountains around; only one mine has been seriously exploited, between 1870 and 1882.

Osmiridium has been obtained in association with gold in New Guinea, and has been exported in small quantities, and a certain amount of silver exists in New Guinea and New Caledonia. Manganese occurs in New Caledonia in the schists of the west coast, and was for a time an important export; deposits also occur in Rurutu (Austral islands), though they have not been worked, and on Babelthuap and Saipan, as well as in the Port Moresby area of Papua and

in New Britain. Copper, zinc, galena (silver-bearing lead sulphide), and cobalt have been obtained in New Caledonia and New Guinea, and small deposits of antimony have been worked on the east coast of New Caledonia. Iron occurs in small quantities in Yap and Ponape (Carolines), and in larger amount in New Caledonia. Though in the last-named island it is of low grade, it was extracted by Japanese interests immediately before the war. Surface iron ores which contain copper occur in New Guinea, and were worked before the war; the material was exported for pigment. Bauxite is found in Palau, Yap and Ponape (Carolines), and is reported to be in such quantity that it would suffice Japanese industry for twenty years; the estimated production in 1939 was about 100,000 tons of ore, yielding about 25,000 tons of aluminium. Sulphur deposits are common in the active volcanic areas, but in view of the low market prices for sulphur, are not worked to any great extent.

In addition to the sources mentioned above, prospecting in some island groups of the Western Pacific, such as the New Hebrides, the Solomons and New Guinea, indicates that there may yet be deposits of these and other minerals which will repay commercial exploitation.

Coal and Oil

All forms of coal are rather rare in the Pacific islands since the rocks are mainly recent. But coal of somewhat low quality has been worked on the west coast of New Caledonia (vol. III, p. 465), bituminous coal and lignite are found in Palau, and there are considerable deposits of anthracite coal (which, however, contains a high proportion of ash) in New Guinea. Lignite deposits, as yet not properly surveyed, occur in Rapa (vol. II, p. 253) and in Papua. Traces of petroleum have been found in New Caledonia (at Koumac), and there appear to be considerable petroleum reserves in New Guinea, where much prospecting has been done; there has already been some production of oil from Dutch New Guinea.

AGE AND ORIGIN OF THE PACIFIC

How long has the Pacific area been sea and how was the great depression formed? These are questions which it is impossible to answer with certainty and in consequence speculation has ranged over a host of possibilities. It has even been suggested that a continent has disappeared in the Pacific since the dawn of the human period and that the island populations are the remnants of continental

peoples who retreated to the tops of the mountains when the great submergence took place. In this connection it is pointed out that were Africa to subside by 15,000 feet its site would be deep ocean with (except for Ruwenzori) volcanic islands comparable with those of the Pacific. But the idea of a Pacific continent in human times is a fantasy—the Polynesian is a canoe man, not a pedestrian. Some geologists have postulated large tracts of land across the Pacific at various geological periods in order to account for the distributions of fossil animals. But there is no general agreement about this, and some think that the evidence is best explained on the basis of a permanent ocean.

The rocks above sea-level of the islands of the Pacific basin (in the geologist's terminology) are all of late geological age (Tertiary and later); the age of the rocks below them in the 'rises' is unknown. All the evidence indicates that the 'rises' are accumulations of volcanic material and that they are not upfolds of the sea floor similar to the fold ranges of the continents. Seismic evidence shows that at the boundary of the Pacific the difference in physical properties between the more rigid oceanic crust and the continental crust is traceable to a depth of about 30 miles, below which it disappears. The material near the surface of the Pacific floor does not differ significantly in physical properties from that for several hundred miles below it—a condition different from that in the continental areas. In qualification of this statement it should be noted that the smaller depth of the Albatross plateau and the extension of the seismic belt over it indicate the presence of a thin layer of lighter continental rock. The Pacific earth crust appears to be of remarkable strength compared with that of the continental crust. Loads of ice a few thousands of feet thick have pressed down the continental crust hundreds of feet, but big loads of volcanic rock in the Pacific islands have not had this effect. The shores of the islands have not been moved vertically by as much as a thousand feet during the last 60 million years, proving great stability of the ocean floor on which the islands rest. This is all the more significant as during this period there were great crumplings and uplifts of the continents which formed the Alps, Himalayas, Rockies, Andes, etc. The strongest reason for regarding the Pacific depression as a permanent one is the fact that the continents stand high and the ocean floors low because they are light and heavy masses respectively—the continents are floating rafts—and the geologist knows of no likely means by which this fundamental density difference could be reversed. In support

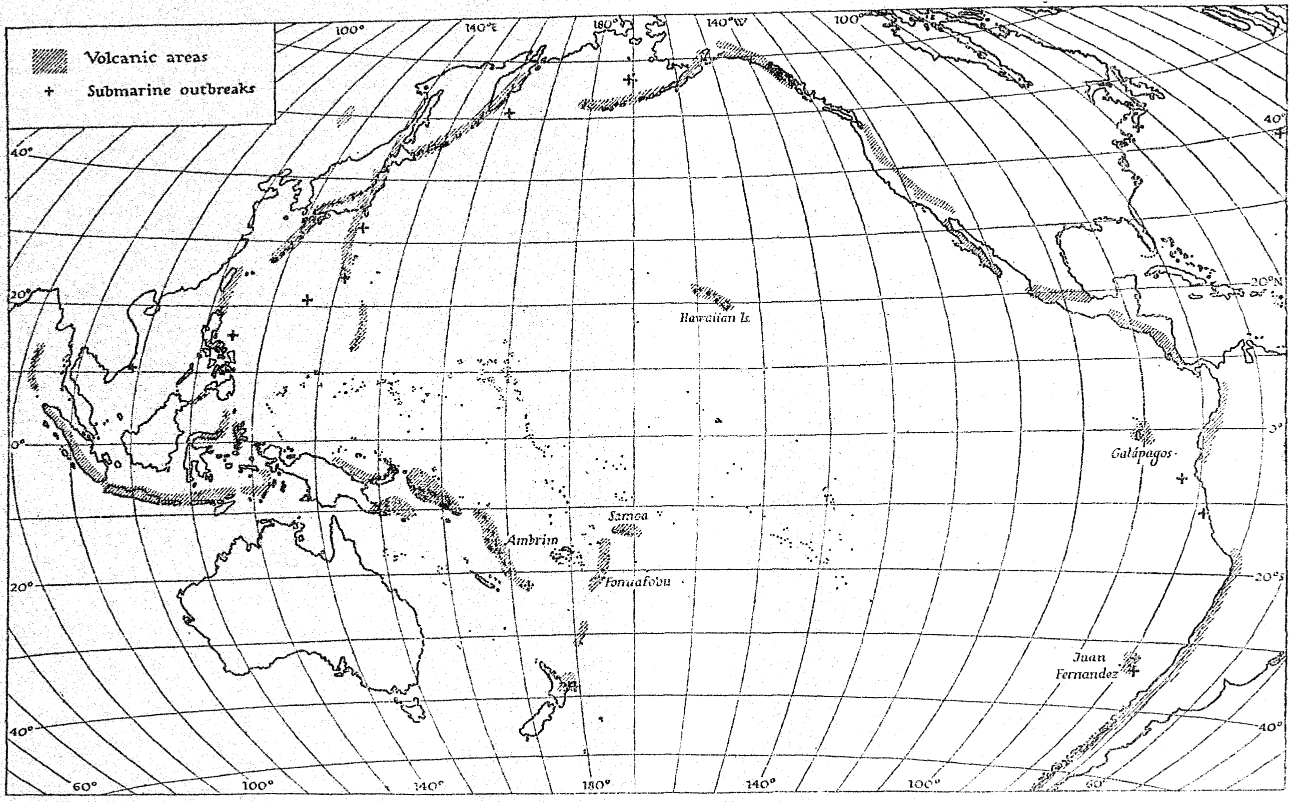


Fig. 8. Volcanic areas of the Pacific

The shaded areas are regions of active vulcanism. The crosses mark isolated outbreaks. Based on K. Sapper, *Vulkankunde*, plate 34 (Stuttgart, 1927).

of this conclusion there is no evidence that the continents have ever been covered by deep sea.

The problem of the origin of the Pacific hollow is bound up with the larger problem of the restriction of the lightest rocks of the earth to the continental sectors. The earth is built up of a series of concentric shells decreasing in density towards the surface. The shells are continuous with the exception of the outermost and lightest one, the continental crust, and why this is discontinuous and absent from the deep oceans is one of the great unsolved problems of geology. One line of thought relates the matter to the theory that the moon was once part of the earth, and it has been suggested that the Pacific depression is the scar marking the place where the moon material came off. That this is no simple conception will be realized when it is remembered that the volume of the moon is thirty times that of the Pacific. The idea may be entertained in the following form. We may imagine the earth after birth from the sun to have developed a continuous outer shell of light rock. Then as a result of tidal action the moon mass was torn from the outer and less dense shells of the earth, taking the greater part of the lightest shell with it. The specific gravity of the moon is 3·34, that of the earth 5·52. If any such event ever took place it was at the beginning of geological time. With this cataclysm one may imagine that the continental slab left behind broke up into its present fragments, which drifted towards the main Pacific 'scar' to their present positions. According to another theory this fragmentation and separation by drift has been going on through geological times and is perhaps still in progress. But all this is speculation.

The Borders of the Basin

At the borders of the Pacific basin conditions are different and exceedingly complex. Here in the north and west are the arcuate lines of islands and fore-deeps, the zone of great volcanic and earthquake activity and of uplift—the circum-Pacific belt where the earth's crust is alive. The curved lines of islands, deeps, and volcanoes appear to mark the outcrop on the world sphere of several planes which dip away from the ocean and along which differential movement is going on. Fig. 12 illustrates this conception. Determinations of the force of gravity indicate that at the deeps the earth's crust is being dragged or pushed down. The belt is one in which tangential compressive forces are in operation. One explanation

is based on the hypothesis of a cooling and contracting inner earth with the consequent growth of crustal compressive stresses in the outer layer, which find relief where the Pacific floor abuts against the weaker continental crust. The situation in the Pacific ocean regions outside the basin in past geological times is obscure. The extra-basin lines of islands contain continental rocks and appear to be the remnants of old mountain chains. The islands were larger in the past and were probably joined as long tracts of land but for the reasons given above the conception of continuous land between the islands and the continents where now are wide stretches of deep sea must be regarded with reserve.

All along the margins of New Guinea there is evidence of great earth movements, which were probably initiated in late Miocene time after the foundering of the land in the early Tertiary and reached their maximum in the Pliocene or early Pleistocene. These movements were probably responsible for the appearance of New Britain as a distinct island, and possibly for the formation of Murua (Woodlark) which has raised coral limestone platforms 200 ft. high along its north coast. In the New Guinea area and among the island arcs which curve south-eastwards from it, earth movements continued throughout the Pleistocene and into the 'recent' period of geological time; active sinking still continues along the south coast of New Guinea. As evidence of an uplift of land several platforms of coral limestone, which reach a maximum height of 1,500 ft., are found along the south-east coast of New Britain. Misima island has been affected by five distinct elevations within the Pleistocene and recent periods. Here five coral limestone terraces can be traced in an ascending series at intervals of roughly 200 ft. The flat portions of the terraces carry thin layers of sand with the remains of a recent marine fauna. Choiseul in the Solomons has limestone terraces at heights of 400, 800, and 1,200 ft. Smaller islands in this region, such as the Trobriand, Laughlan and Conflict islands have volcanic rocks or sediments of the Tertiary period which have been eroded and are capped by raised coral limestone reefs which were formed in Pleistocene times. As in other parts of the Pacific, these raised coral limestones are of fundamental importance in providing good soil for native agriculture. If the raised coral is interbedded with volcanic material (or has a thin veneer of volcanic formations as in the Duke of York islands, where the two formations form a terrace varying in height from 50 to 60 ft.), it provides a very fertile soil. This is also true of the soil weathered from low shore terraces

resulting from changes in sea level. That elevation of parts of the islands still continues is shown by a datum mark on Treasury (Solomon islands), which reveals a rise of a foot in the period 1882–1932.

CHANGES IN SEA-LEVEL

After a fall of sea-level, raised shores remain to mark its former position, which can be determined from them with considerable precision. With a rise of sea-level estimates of the former position can be made (albeit with less precision) from the depths of submerged shore platforms and drowned river valleys. In interpreting such evidence, there is, however, the complication that similar results are produced by vertical displacement of the earth's crust, with no change in sea-level. As the oceans are inter-communicating the effects of sea-level changes are world-wide, whereas movements of the crust are local—upwards in one region, downwards in another. The crust has been continuously undergoing differential displacement through geological time—at certain periods relatively rapidly—and it is quite impossible to discover what changes of sea-level have occurred in past geological ages. This especially applies to the Pacific region, in which earth movement has been particularly active in Tertiary times. It is only for the geologically most recent period, from the beginning of the Ice Age to the present day, that unambiguous evidence can be obtained of changes in sea-level. These changes have left their mark over all the earth, as in most areas they have been more rapid than the slow crustal movements.

Old shore levels are found at from 50 to 100 ft., while a former shore now at 15 to 20 ft. can be recognized on many coasts the world over—it is, for example, well marked in Samoa, where it is seen as a flat belt of coral debris partly covered by lava flows, and in Norfolk island. This lower raised shore is the best preserved and last to be found of the shore levels indicating a fall of sea-level. Terraces are found at lower levels than 15 ft., and indicate halts in the gradual fall of the sea to its present level.

In Rurutu in the Austral islands, deposits of coral debris and sand lie from 6 to 8 ft. and limestone shelves from 1 to 2 ft. above high water mark. In Rapa, in the same region, the limestone shelf along the shore lies at a height of 3 ft. above sea-level. There are similar shelves of coral limestone at heights of 2 ft. in Napuka (Tuamotu archipelago) and Tapuaemanu (Society islands); and at

5–6 ft. above high water in Viti Levu (Fiji), 'Eua (Tonga—Fig. 15), Moorea and Borabora (Society islands). On Tahiti these shelves take the form of low detritus-covered flats, formerly coral reefs, which lie a few feet above high water mark, and may be from 1 to 1,000 yd. wide. The emerged shore flats of Borabora are similar and vary in width from a few feet to more than 200 yd. Here, as elsewhere, the spreads of coral debris fragments and disintegrated volcanic material provide a rich loamy soil. In Yap the benches with their cover of marine sand are from 3 to 6 ft. high. Plate 8 shows five levels of erosion in Vatu Lele, Fiji.

Uplifts of the land, as distinct from changes in sea-level, produce high terraces of emerged littoral sediments around the coasts. This has been noticed in Oahu (p. 50). and is a feature of other Hawaiian islands. Elevated wave-cut platforms covered with volcanic and coral limestone boulders occur at 15 ft. in Kauai (Plate 9), and at 100 ft. in Niihau, where the platform continues inland to the base of the denuded volcanic dome at the centre of the island, and forms a flat plain broken by volcanic or sedimentary knolls which were previously islands. As an example of a fall in sea-level there is an additional series of low benches along the shore of Niihau.

The world-wide existence of submerged banks which clearly represent one-time land surfaces demonstrates a former sea-level about 300 ft. below the present one.

It is not imagined that these changes in sea-level have been due, to any appreciable extent, to changes in the capacities of the ocean basins or to losses and gains in the amount of world surface water. They can reasonably be ascribed to abstraction and addition of ocean water by transference to and from the land areas, with formation and melting of glaciers during the cold glacial and warm inter-glacial epochs respectively. It is estimated that melting away of the present glaciers of the world would result in a rise of sea-level of 150 ft., whilst at the time of maximum glaciation the sea-level was 300 ft. lower than at present. This latter estimate tallies with the position of sea-level deduced from the drowned shores. The old shore-level of 50 to 100 ft. may be ascribed to some inter-glacial period when there was less ice on the lands and more water in the sea than at present. The most recent change of level, a fall of 15 to 20 ft., may perhaps be due to the refrigeration of the climate and growth of glaciers which set in after the 'post-glacial optimum' about 4,000 years ago.

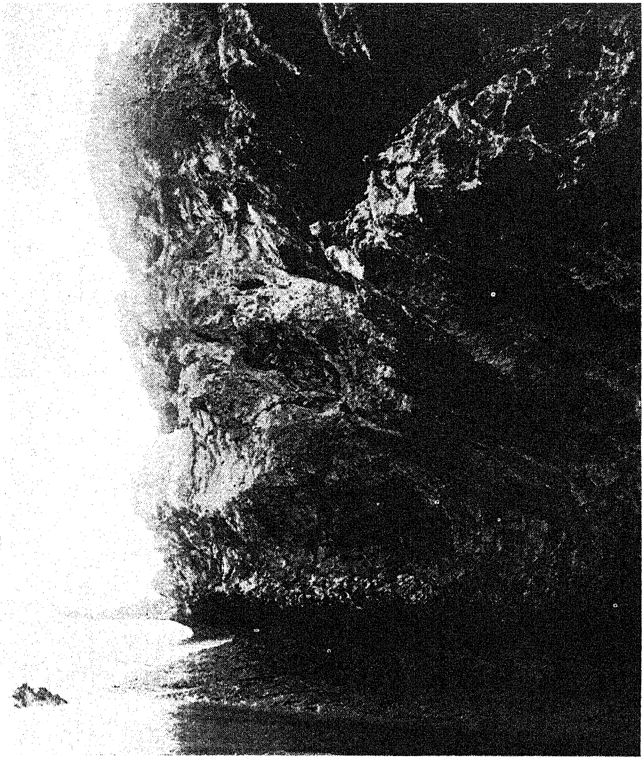
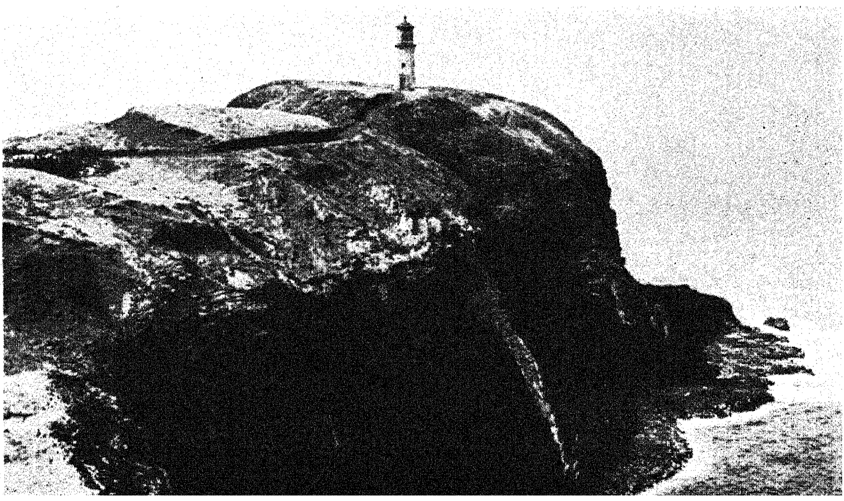


Plate 8. Five levels of erosion, Vatu Lele, Fiji
This plate shows the progressive undercutting of a limestone cliff as the land has risen relative to the level of the sea.



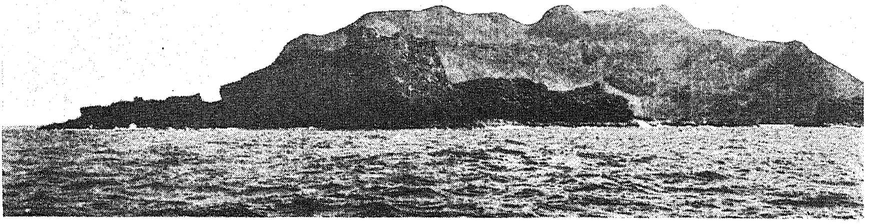


Plate 10. Akamaru island, Mangareva
Akamaru, with the island of Makapu (in the foreground), forms the western rim of the former Akamaru-Makapu crater.

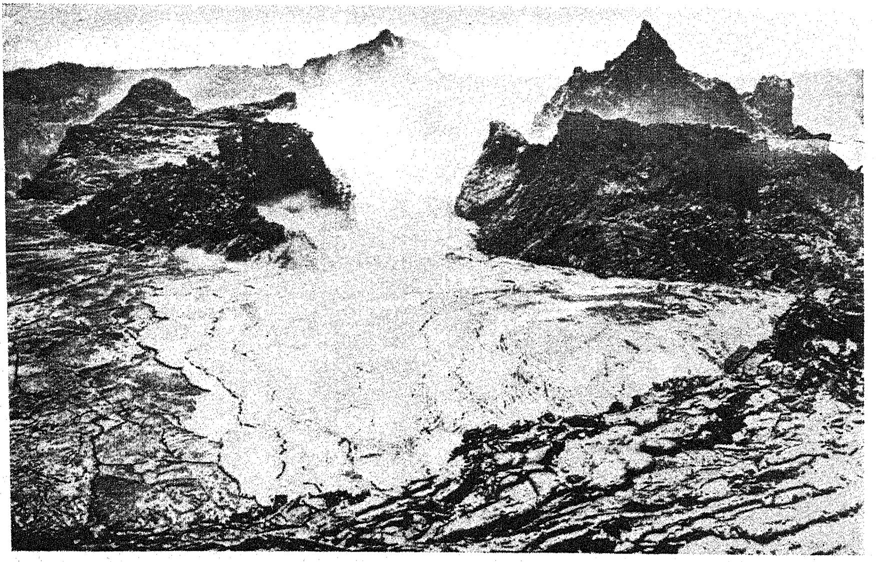


Plate 11. Halemaumau crater, Hawaii
This photograph of the interior of the crater was taken on 20 September 1921. In the foreground is the crust on the north pool of the main lake. The crust is breaking up into individual blocks and sinking beneath the surface of the liquid lava. The crags are old overflow platforms inside the crater which have been lifted and tilted by the molten mass.

ACTIVE AND EXTINCT VOLCANOES

The boundary of the Pacific is commonly spoken of as a 'ring of fire', and a map showing the distribution of the volcanoes which have been active in historic times demonstrates this ring (Fig. 8). Comparison with Fig. 2 shows that the andesite line or border of the Pacific basin where it departs from the ocean border is also a zone of activity. Within the basin most of the volcanoes have long been extinct. Since the entry of Europeans into the Pacific area activity has occurred in the Hawaiian islands, the Marianas, Samoa, New Guinea, the Solomons, the New Hebrides, Tonga, and the Galápagos. Submarine eruptions have been reported from the neighbourhood of Juan Fernández, from between Laysan and Kauai (Hawaiian islands), and from lat. 7° 30′ S, long. 83° 30′ W (see list on p. 29 for details of eruptions). The Hawaiian Volcano Research Association was founded in 1911 for the study of volcanoes in and around the Pacific. There is a research laboratory in Hawaii National Park, and under the auspices of the University of Hawaii an illustrated quarterly publication, *The Volcano Letter*, is issued. It deals with volcanoes and other related topics in a manner intelligible to the layman. (For details of the Observatory on the edge of Kilauea crater, Hawaii, see vol. II, p. 303.) It is estimated that since the fifteenth century about 2.2 cubic miles of lava, besides great amounts of ash and other fragmental deposits, have been extruded in the Pacific basin. This production for so great an area is insignificant, and it is small compared with that of the boundary zones. From 1895 to 1913, 90% of the explosive eruptions of the Pacific area were in the border region (i.e., eruptions other than lava flows, or lava flows with ash deposition). Since A.D. 1500, as shown by a census made by workers at the Kilauea Observatory, 57 major volcanoes of the world have erupted 98 times and 190,000 people have lost their lives as a result. Casualties in the whole Pacific area have been less than in the more densely peopled East and West Indies. In the Indo-Atlantic half of the world there are approximately 94 active volcanoes, but for the Pacific half the figure is 336.

A comparison of Figs. 6 and 8 reveals that the frequency of volcanoes is often greatest in the neighbourhood of the ocean deeps. This is true, for example, in Japan and along the Andean coast of South America. In the andesite zone a south-west to north-east line of volcanoes with its terminal points at Ruapehu (New Zealand) and Fonualei (Tonga) lies to the west of the Kermadec-Tonga deep.

The Tonga deep bends north-westward as it points toward Suva, and the line of volcanoes which includes Niuafo'ou (Tonga) bends with it. The list of volcanic eruptions includes records from the Marianas. These islands are the summits of a submarine ridge with a basement of andesite and quartz-trachyte, and here again a trench more than 3,281 fathoms deep lies against the convex eastern side of the ridge.

The New Guinea area has already been cited as one in which great earth movements have occurred relatively recently. Five lines of volcanoes, each associated with fractures in the earth's crust, have been identified here. The first line includes the Schouten islands. The second reaches through the islands lying off the north coast of New Guinea and includes Manam, Karkar, Bagabag, the Crown and Long islands, Umboi and Tangi (New Britain). Branching off the second arc lies the third line running from Tolokiwa through Sakar, the Ritter islands, Talawe (New Britain), Langila and Bula, to the extinct volcano mount Schrader. The fourth has been called the Vitu alinement, and the fifth branches off from New Ireland into the Solomons and New Hebrides. In northern New Britain a line which includes several of the active volcanoes listed on p. 30 is to be found in the Willaumez peninsula and around Kimbe bay. It terminates in the east in Ulawun.

The individual volcanoes, active and extinct, are described in the detailed accounts of the islands in vols. II–IV. Even where activity has been long extinct and erosive forces have attacked the volcanic piles, the sites of cones and crater hollows can usually be deciphered from the remnants. A striking feature is the great number of calderas—or abnormally large craters, several miles in diameter—some occupied by lakes, others at sea-level breached to form characteristic circular bays (Plate 10). It used to be thought that these calderas had been formed by colossal explosions whereby the tops of large cones had been blown right away. (In 1937 publicity was given to a seaman's yarn that the peak of Krakatau was blown for 800 miles in the great eruption of 1883, to form an island in the Indian ocean where it fell.) Further study, and especially the evidence provided by the formation in 1883 of a caldera at Krakatau, makes it more likely that these huge craters were formed by subsidence. With a great eruption, rock is 'cored' from the walls of the volcanic chimney by the friction of the escaping material shot out from beneath. Expulsion of liquid from the subterranean reservoir leaves a cavity, and the central part of the cone collapses

into this and into the enlarged chimney. Subsequently with renewed activity new cones may arise on the caldera floor (Fig. 9). The dying stages of activity in individual volcanoes, as represented by hot springs, geysers, boiling mud and water, are well represented in the Pacific, notably in Hawaii and in the north-east of New

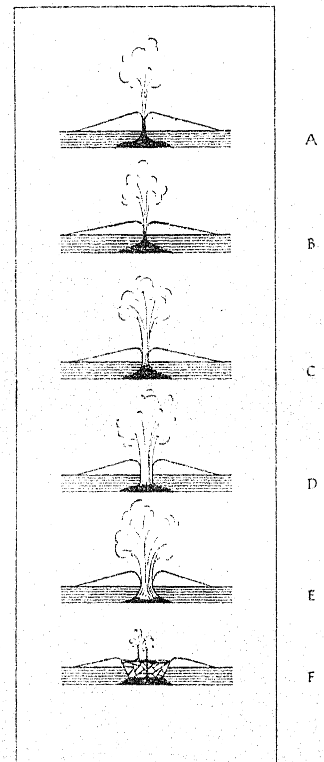


Fig. 9. The formation of a caldera

A hypothetical reconstruction showing the progressive expulsion of the magma (black) as ash, with concomitant widening of the volcanic pipe (C, D and E), and the final collapse with later extrusion of lava on the caldera floor (F). Based on Van Bemmelen, *Het Caldera Problem*, p. 21 (Batavia, 1929).

Guinea. Plate 12 shows a steam-blast eruption in Hawaii in 1924, and Plate 14 the lava spatter resulting from an eruption in 1923.

Most of the islands of the Pacific basin were formed in Tertiary times. The Hawaiian islands are largely built up of fluid lavas

which well up from the craters (i.e., 'shield' volcano activity, Plate 11), whilst fragmental products predominate in the islands of the south-west Pacific. (For *pahoehoe* (smooth) and *aa* (rough) lavas in Hawaii, see Plates 13, 15, and vol. II, p. 304 and Plate 61.) The birth of a volcanic island has been witnessed in recent times in the formation of Fonuafo'ou (Falcon island), Tonga, and its history is that of a swaying struggle between the forces of volcanic accumulation and marine destruction. Bogoslof island (Aleutians), which seems to have appeared about 1768, has a similar history. In 1865 H.M.S. *Falcon* reported a shoal. H.M.S. *Sappho* reported smoke issuing from this shoal in 1877. In 1889 there was an island $1\frac{1}{4}$ miles long and 1 mile wide and 153 ft. high. This was reduced to a shoal by 1898, and was a submarine bank in 1913. In 1927 the volcano again erupted and an island was formed, 300 ft. high and 3 miles in circumference. In November 1940, it was only 20 to 30 ft. high. It was composed of cinders and loose volcanic ash. No growing coral has been found on Falcon island at any stage in its history. (For a more detailed account see vol. III, pp. 24–8.) Falcon island may be regarded as at stage 1 of island formation in the South Seas. Extinction of volcanic activity may be followed by the formation of a submarine bank—stage 2. If at this point subsidence occurs, submarine deposits will accumulate on the bank—stage 3. If the bank is below the depth of reef-building corals, foraminifera and algæ will be the important limestone builders until a level is attained at which corals can live and an atoll may be formed. With uplift a limestone island —stage 4—will result. ('Eua, in the Tonga group, which is an example of stage 4, is described in vol. III, pp. 18–21.)

Where upheaval and volcanic action occur together, major changes in coastal topography may occur. In 1913, in Ambrim (New Hebrides), the coastline shifted to a distance of one mile, and the whole coastal region was uplifted several feet. Compensating subsidence occurred in other parts of the region. The volcanoes involved were mounts Benbow and Marum.

Volcanic Activity Recorded since the Sixteenth Century

The following Table gives a list of known outbreaks from the sixteenth century, so far as records are accessible, but it is not necessarily complete.

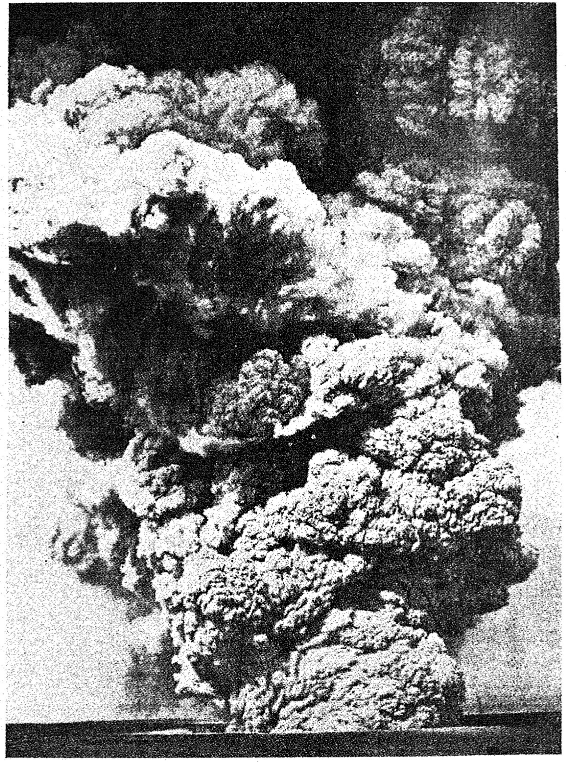


Plate 12. Steam blast eruption, Halemaumau

This photograph was taken about 0830 hr., 22 May 1924. Note the tendency towards a spiral vortex in the dark, electrically charged cloud above.

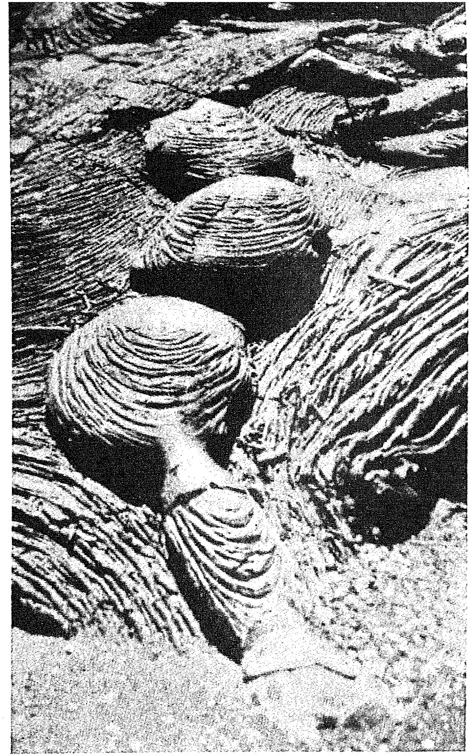


Plate 13. Toes of *pahoehoe* lava

This lava was erupted in 1919 on to the north floor of Kilauea crater, Hawaii.

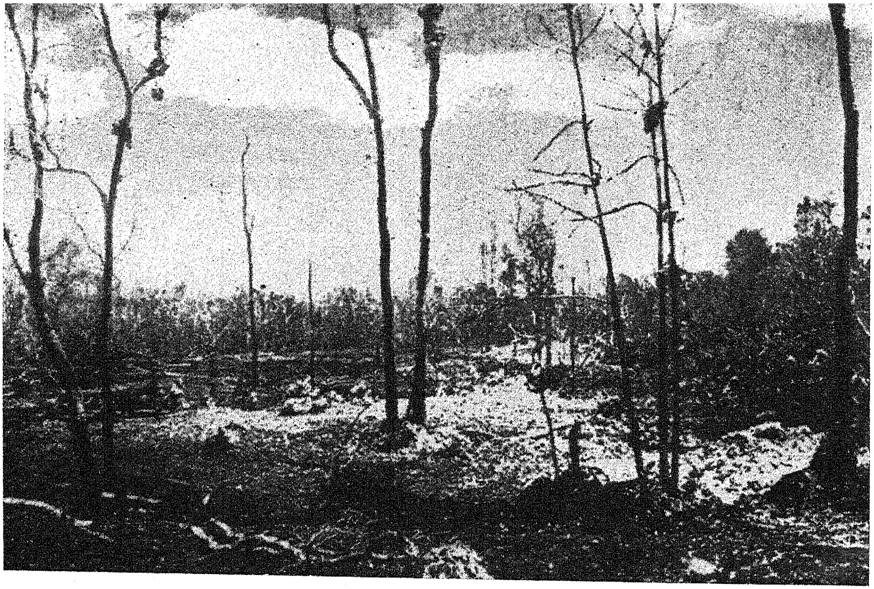
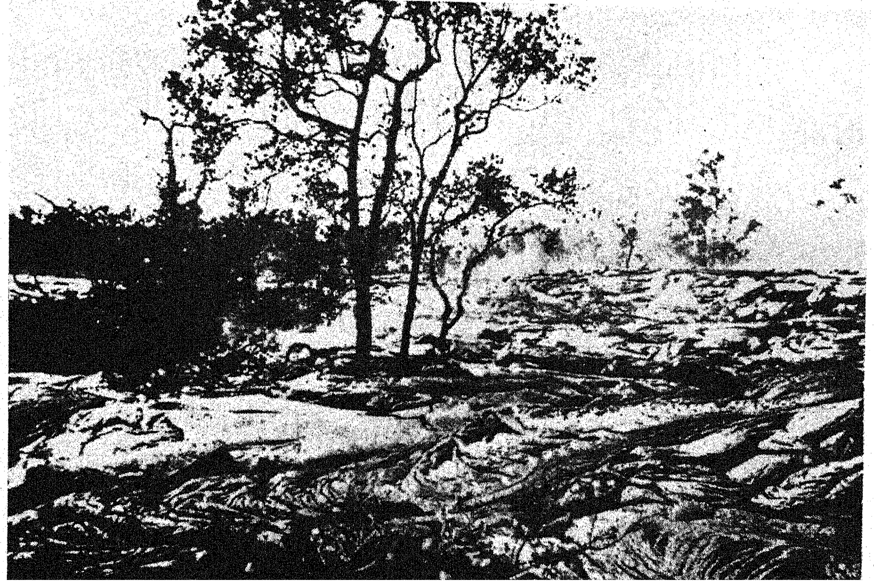


Plate 14. Lava spatter, Hawaii

The after-effects of an eruption on 25 August 1923, west of Makaopuhi. The lava spatter is seen in the trees. There is a deposit of sulphur along the flow-crack in the forest.



Juan Fernández Area

Submarine outbreaks are as follows:

1. One mile off Punta Bacalao (1835).
2. After a seaquake several islands formed at 33° 34′ s, 76° 49′ w; at 33° 40′ s, 76° 49′ w; and at 33° 20′ s, 78° 20′ w (1839).
3. After a seaquake in 34° 55′ s, 77° 38′ w, dead fish came to the surface and the sea water was observed to be of milky colour (1867).

Galápagos

1. On Fernandina four volcanoes were active in 1813, and two in 1814. Lava flows were observed in 1825. Eruptions were recorded in 1928, and in the south of the island in 1937.
2. On Isabela activity was observed in 1797, 1800, 1813, 1835, and 1844. In April, 1925, lava flowed into the sea on the northern coast. There was an eruption south of cape Berkeley in 1928.
3. On Floreana there were eruptions in 1813 in the centre and in 1897 in the south of the island.
4. On San Salvador there was activity in 1899.
5. An isolated submarine outbreak has occurred in 83° 20′ w, 7° 30′ s.

Hawaiian Islands

1. Haleakala (Maui) last erupted about 1750.
2. Hualalai (Hawaii) last erupted in 1800–1.
3. Mauna Loa last erupted in 1943, and erupts on an average every 4½ years.
4. Kilauea is almost continuously eruptive.

Submarine outbreaks:

1. Liquid rock (magma) withdrawing from Kilauea in 1868 appeared on the ocean floor.
2. In 1877 there was an eruption in Kealakekua bay due west of the summit of Mauna Loa.
3. In 1880 there was a pumice outbreak off the north-east coast of Hawaii.
4. In 1906 what was probably a pumice outbreak occurred between Laysan and Kauai.
5. In 1850 an isolated submarine outbreak was recorded in 20° 56′ N, 134° 35′ E.

Marianas

Dates of eruptions here are as follows :

1. Uracas (Farallon de Pajaros) in 1865, 1875, 1901 and 1912.
2. Guguan in 1901.
3. Pagan in 1922.
4. Asuncion island in 1906.
5. In 1846 a great floating pumice area, possibly from the Marianas, appeared in 16° N, 125° E.

Islands off the North-east Coast of New Guinea

Eruptions have been recorded in the Schouten islands at :

1. Blupblup (Garnot) in 1616.
2. Kadovar (Blosseville) in 1616 and 1700.
3. Bam (Lesson) in 1616, 1909 and 1919.

Other eruptions in the islands off New Guinea were :

1. Manam in 1616, 1643, 1845, 1877, 1887, 1889, 1895, 1902, 1910, 1917, 1919, 1921, 1936, and 1937.
2. Karkar in 1643 and 1895.
3. The eruptions in the south-east of New Guinea are little known, but there are indications of recent activity in the areas around mounts Victory and Trafalgar.
4. The Ritter islands in Dampier strait had eruptions in 1700, 1793, 1887 and 1888.

North Coast of New Britain

1. Tangi and Talawe were active shortly before 1890.
2. Pago (Bango) was active between 1900 and 1910, and in 1912.
3. Langila was active between 1900 and 1910.
4. In the Willaumez peninsula mount Banda erupted about 1910 and Bula is semi-active.
5. Ulawun (The Father) erupted in 1770, 1912, 1915 and 1937.
6. Bamus (The South Son) was active in 1899 and 1912.
7. In Lolobau island (Namisko) there was an eruption in 1905.
8. Tavurvur (Matupi) erupted in 1767, 1791, 1878, 1937 and 1941.
9. At Sulphur creek there was activity about 1850.
10. A submarine outbreak occurred off Rabaul, in Blanche bay, in 1878. Volcano island was formed then. In 1937 there was a serious eruption off the Rabaul area, coinciding with that of Matupi, which lies on the south-east side of Blanche bay.

Solomon Islands

1. On Bougainville island, Bagana erupted in 1874, a few years before 1900, in 1908 and in 1938.
2. Mendaña reported an eruption on Savo in 1568, and later ones occurred in 1820 and 1850.

Santa Cruz—New Hebrides

Eruptions have been reported as follows :

1. Tinakula in 1595, 1767, 1797, 1869, 1871, 1886 and 1909.
2. Vanua Lava in 1856 and 1861.
3. Mounts Benbow and Marum (Ambrim) in 1863, 1864, 1871, 1888, 1894, 1908, 1912, 1913, 1929 and 1937.
4. Lopevi, in 1863, 1864, 1884, and several times since then, the latest being in 1939.
5. Yasur (Tana) is almost continuously active.
6. Hunter (Fearn) island in 1841, 1895 and 1903.

Submarine outbreaks :

1. Between Epi and Tongoa in 1897 and 1901.
2. Between Traitor's Head (Eromanga) and High rock in 1881.

Samoa

1. In Savai'i there was a lava flow in the north-west in 1700. Two new parasitic cones were formed to the north of Maunga Afi in 1760. In 1902 a second crater formed in the west.
2. At Matavanu activity lasted from 1905 to 1911 (Plate 16).
3. There was a submarine outbreak in 1866 near Olosenga in 14° 13′ s, 169° 34′ w.

Tonga Area

Eruptions have been recorded as follows :

1. Niuafo'ou about 1814, in 1853, 1867, 1886, 1887, 1912, 1923, 1929, 1935 and 1943.
2. Fonualei in 1791, 1847, 1897, 1937, 1938, 1939.
3. Late island in 1790 and 1854.
4. Metis shoal was formed in 1858. In 1878 it was an islet 110ft. high. It was still active in 1886, but it was 2 fathoms below sea-level in 1898.
5. Tofua in 1774, 1792, 1854, 1900 and 1906.
6. Falcon island (Fonuafo'ou) was last reported to be in eruption in 1936.

Submarine outbreaks in this area occurred :

1. In 1874, between Ha'apai and Tongatapu.
2. In 1907, in 21° 27′ s, 175° 47′ w.
3. In 1911, in 20° 50′ s, 175° 33′ w.
4. In 1912, two miles south-east of Hunga Ha'apai.
5. In 1928, a pumice eruption in 17° 25′ s, 176° 09′ w.
6. In 1932, thirty miles south-west of the west end of Tongatapu.
7. In 1939, about one mile south-east of Niuafo'ou.

Kermadec Area

1. An island arose in Denham bay in 1870–72, and disappeared in 1877. There was an outbreak in the central crater in 1872.
2. Curtis island had an eruption in 1899.

Submarine outbreaks occurred in the area :

1. In 1825, in 30° 14′ s, 178° 55′ w.
2. In 1870, near Raoul island, in 29° 14′ s, 177° 55′ w.
3. In 1886, in 29° 11′ s, 177° 52′ w.

EARTHQUAKES

An earthquake is a shaking of the ground and in comparatively rare instances is associated with a permanent displacement of a few feet. The movement is in a vertical or horizontal direction or both. The place beneath the surface where the shock originates is called the focus, and the position at the surface vertically above this is the epicentre. According to depth of focus earthquakes are classified as :

Normal—focus less than 40 miles down (commonly 6 to 10 miles).

Intermediate—focus from 40 to 150 miles down.

Deep—focus from 150 to 450 miles down.

Fig. 10 shows the distribution of the Pacific regions which are especially subject to earthquakes. The main feature is a belt almost completely encircling the Pacific basin with an arm running from southern Chile to Easter island, and then 2,600 miles to the south-west. At its nearest point this arm is separated from the western part of the belt by 1,800 miles. All the great deeps occur within the belt.

The great majority of Pacific earthquakes have foci at normal depth. Some are definitely related to volcanic activity and give evidence of movement of rock liquid within the crust. Others are due to sudden displacements along fractures in the solid crust;

intermediate and deep ones are probably all of this type. The earthquakes of the Hawaiian islands are chiefly due to volcanic activity. Those occurring in 1929 in the area around the volcano of Hualala, are thought to have resulted from movement of magma (molten rock)

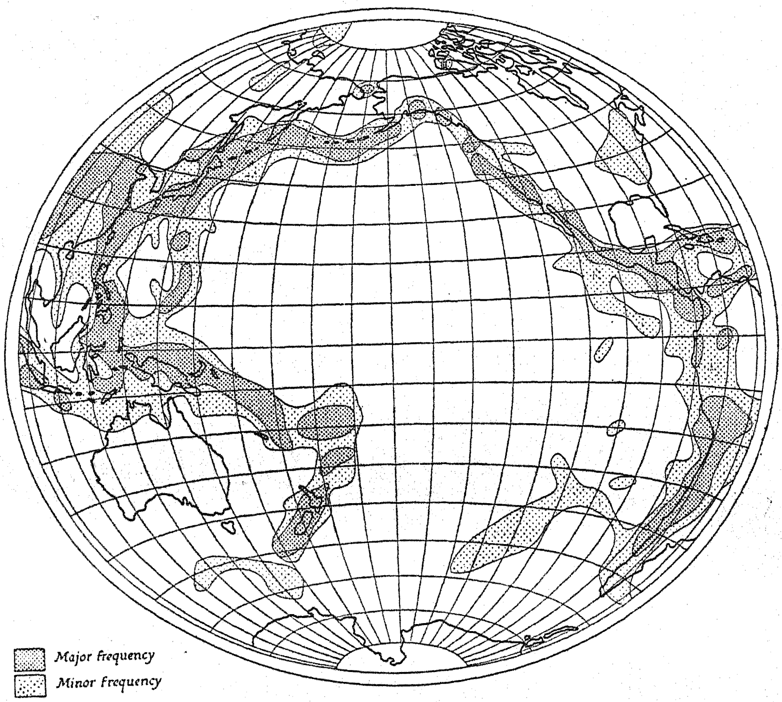


Fig. 10. Earthquake belts of the Pacific ocean

The areas of occurrence of earthquakes are shaded according to frequency. This map may be compared with Fig. 8. Based on N.-H. Heck, *Earthquakes*, p. 110 (Princeton and London, 1936).

which passed into Hualalai from beneath Mauna Loa (vol. II, p. 302). There have, however, been strong shocks, notably in 1868 and in 1929, which may have been of deeper origin. To cite an example of permanent displacement, destructive shocks occurred in the vicinity of Kapoho, the east point of the island of Hawaii in 1924. A block of land subsided by amounts of up to as much as 11 ft., and a new lagoon 100 yd. across was formed with coconut palms standing in 8 ft. of water. In the northern Pacific belt where horizontal displacements have taken place (in California, Japan and the Philippines), the continental sides have moved southwards

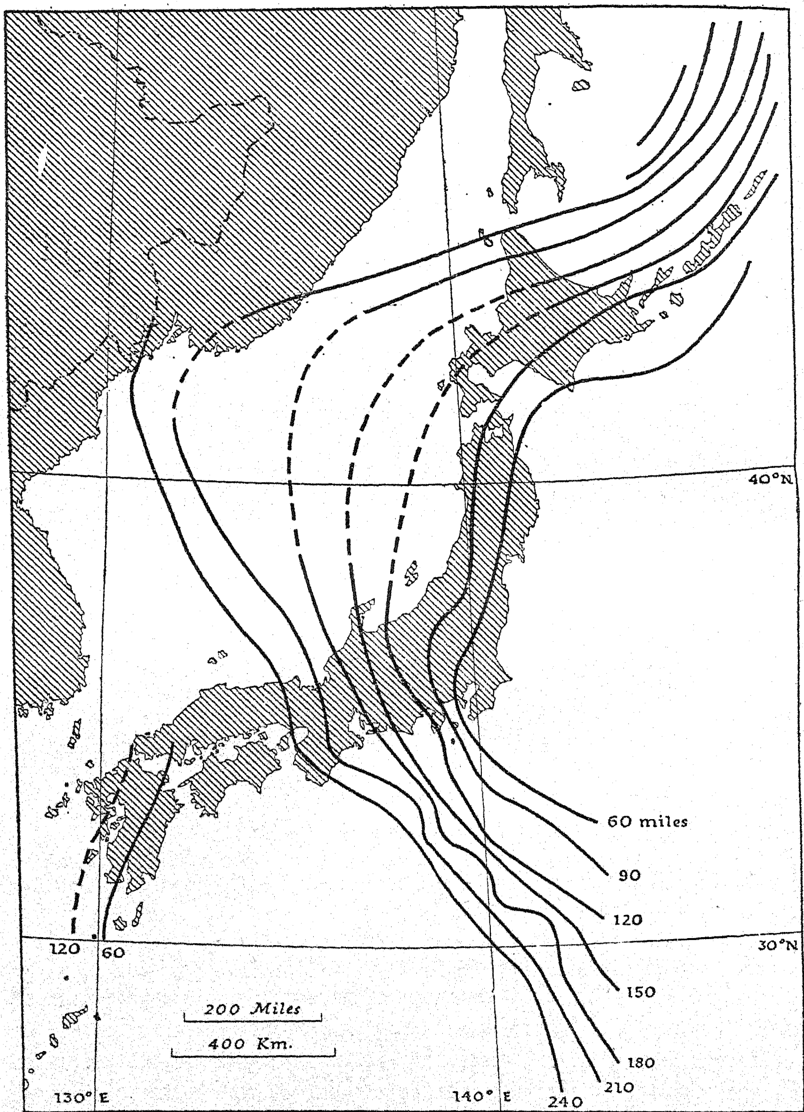


Fig. 11. Increase in depth of earthquake foci towards the Asiatic continent

Each heavy line is drawn through the epicentres of earthquakes at equal focal depths. In the absence of seismic records the broken lines are inferential. Based on John Milne, *Earthquakes and other Earth Movements*, p. 154 (new edition by A. W. Lee, London, 1939).

relatively to the Pacific side, but more observations are needed before this can be regarded as a rule.

Special interest attaches to the deep earthquakes. Apart from the East Indies they are known only in the circum-Pacific area. The foci of all earthquakes deeper than 200 miles occur close to and on the continental side of the boundary of the ocean, although the alinement of the epicentres is not everywhere strictly parallel to the boundary, as may be seen from Fig. 11. A detailed study of the evidence leads to the conception (illustrated in Fig. 12) that the continental part of the crust is riding up over the oceanic, and the oceanic is thrusting under the continental along great fracture planes inclined away from the ocean at an angle of about 20° and extending to depths of hundreds of miles. Volcanoes are commonly found where the fracture is at a depth of about 60 miles, whilst normal

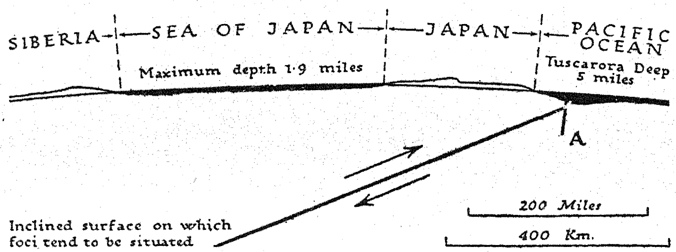


Fig. 12. Distribution of earthquake foci along an east-to-west section through Japan

The line A indicates the range of depths of normal earthquakes. The oblique line drawn from the same point represents a great fracture-plane in the earth's crust; the continental part of the crust (west of the plane) is riding up over the oceanic part (east of the plane). This earth movement gives rise to earthquakes with foci situated on this plane. Based on John Milne, *Earthquakes and other Earth Movements*, p. 179 (new edition by A. W. Lee, London, 1939).

earthquakes with shallow foci occur where the fracture approaches the surface. Fig. 13 shows the alinement of the volcanic rifts of Japan.

Using very sensitive 'tiltmeters' it has been shown in Japan that volcanic eruptions and earthquakes are preceded for years by tilting of the ground, but the time and precise location of coming shock cannot be predicted. There is no doubt that there will be great earthquakes round the Pacific during each coming year. There is no day without small shocks. There need not be any excessive damage, for earthquake-resistant structures can be built at a cost

not much exceeding that of ordinary buildings. All works of construction in the circum-Pacific belt should be made earthquake-proof.

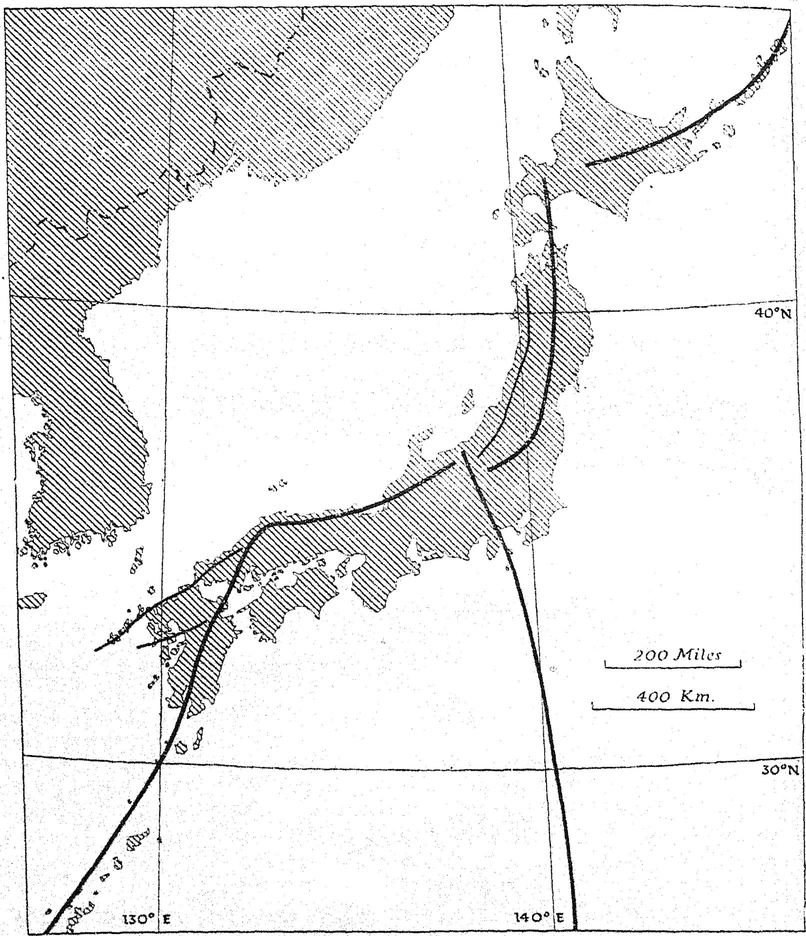


Fig. 13. The volcanic rifts of Japan

The heavy lines indicate the positions of volcanic rifts and their convergence in the central highlands of Honshu. Based on *The Volcano Letter*, no. 323, p. 14 (Hawaiian Volcano Observatory, National Park, Hawaii, 1931).

Seismic Sea Waves

Earthquakes accompanied by vertical displacement of the sea bottom give rise to sea waves which can be detected over the whole Pacific and may cause disasters when they reach shelving shores and flood

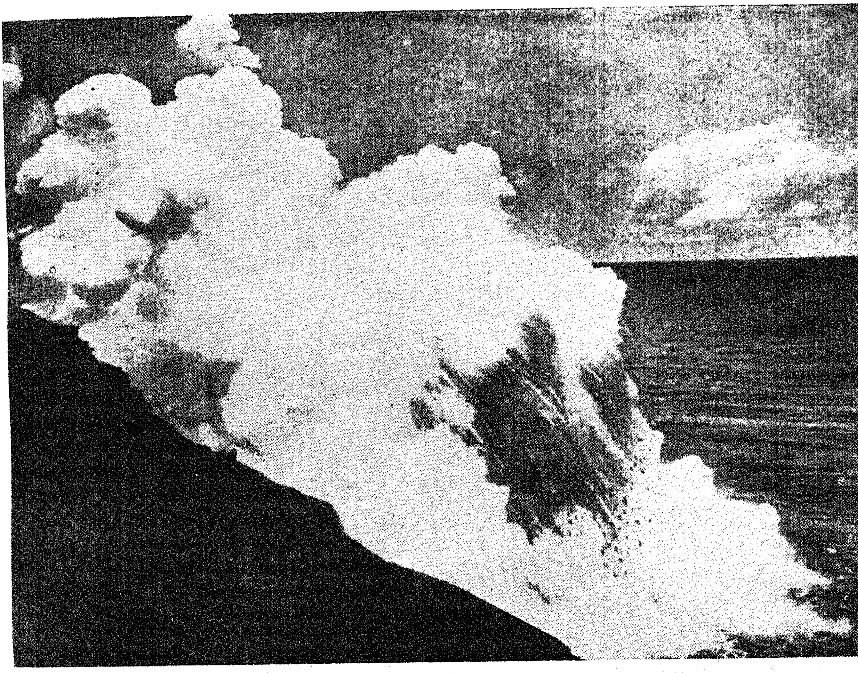


Plate 16. Contact explosion, Matavanu, Savai'i
This explosion followed the fall of lava into the sea.

Plate 17. The eastern face of Mangareva
This view is taken through a gap in the narrow eastern barrier reef. The peak in the distance is mount Duff. The gap in the reef is choked with coral sand washed

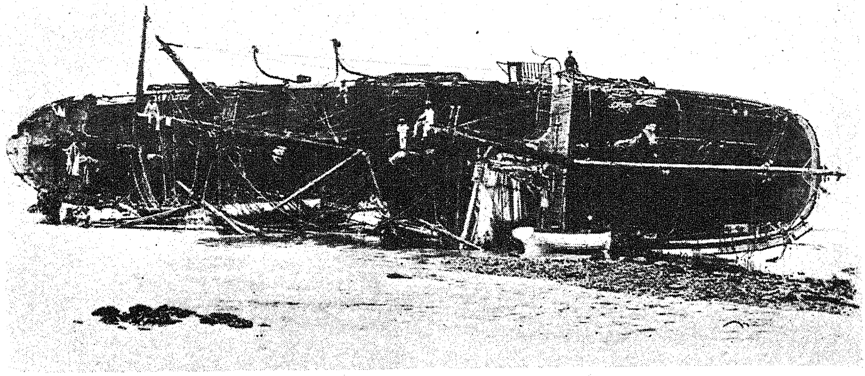


Plate 18. The wreck of the German warship *Adler*
This shows one of the three German warships which, with three American warships, were driven ashore at Apia in 1889 during a violent hurricane.

Plate 19. Wreckage in the Wailoa creek, Hilo
This photograph was taken on 3 February 1923. A tunami had occurred seven hours earlier, after an Aleutian earthquake. Sampans were thrown over the railway bridge at Waiakea station, which was destroyed.

low coastal lands. These seismic sea waves or *tunami* (from Japanese *tu*, a port, and *nami*, a long wave) have been called tidal waves for so long a time that the term will probably persist in everyday English despite the fact that such waves, which may also result from submarine volcanic eruptions, landslips, and cyclones, are in no way related to the tides. Their effects on shipping may be as disastrous as those produced by hurricanes (Plates 18, 19).

In the neighbourhood of the epicentre the effect may be such that the navigator thinks that he has struck a rock. Loose objects may be overturned, bolts and rivets started, and even masts broken. Although the vessel may not be directly over the epicentre the vibrations appear to come from directly underneath. Despite its slight compressibility a mass of water responds as an elastic body to the short-period oscillations of submarine earthquakes, and the vibrations travel towards the sea surface with a velocity equal to that of sound. Such experiences have given rise to the insertion on old charts of some of the numerous shoals and reefs which modern research has shown to be non-existent. The elastic waves may cause fatal damage to the air bladders of fish. Generally fish are caught only with great difficulty a few days before a great seaquake: perhaps they are sensible to the weak fore-shocks which precede great earthquakes. Some kinds of fish on being frightened by a shock swim about in great shoals apparently looking for a place of safety; other kinds migrate to centres of seismic activity, seemingly attracted to such places.

It is the transverse sea waves which may be so formidable. In the open sea they are unnoticeable, being about 100 miles from crest to crest and only a few feet in height. In shallow water the amplitude increases. Strong currents may be set up which mystify the navigator. This may happen even with a comparatively small tunami on approaching the land, especially if there are narrow channels in the direction of its progress. The greatest wave heights are experienced at shelving shores and particularly at the heads of V-shaped bays. The advent of a large tunami is commonly (though not always) heralded by a slow withdrawal of the water, followed by an advancing wall—the most spectacular and appalling of all earthquake phenomena. There may be a series of waves and a later one may be more destructive than the first. In 1896 an earthquake with its epicentre at 4,600 fathoms in the Tuscarora deep caused a tunami which swept the coast lands of Sanriku, Japan, reaching a height of 100 ft. About 2,700 people were killed, and hundreds

of vessels of various kinds were left lining the foothills. The danger to the populations of low coral islands is great. A European in the Fiji group in May 1877, for instance, recorded 'a terrible wave which swept away thousands of the inhabitants of the atoll islands'.

Tunami arriving from great distances may be unnoticed ashore but be marked on the record of the automatic tide gauge. Tunami originating off the coasts of Chile, Japan, and the Aleutians have damaged craft in the harbour of Hilo, Hawaii (Plate 19). When a distant earthquake is recorded on the seismograph on Hawaii and there is a possibility that it was a submarine shock, warnings are issued to the harbour master. From the time elapsing between the arrival of the primary and secondary earth waves the distance away of the epicentre can be determined, and, knowing the velocity of the sea waves, which in the Pacific is about 450 miles per hour, the time of arrival can be predicted. As this is not for some hours after the earth shake from a great distance there is ample time to take precautions. Two examples may be cited.

On 3 October 1931, a distant earthquake was recorded at Hawaii. The secondary earth wave arrived 7½ minutes after the primary one and this interval was found from tables to indicate an epicentre 3,680 miles away. From the direction of the disturbance of the seismograph pendulums the epicentre was deduced to lie either to the north-east or the south-west. If to the north-east it would have been in North America and therefore there would be no water wave. If to the south-west, it would have been off New Caledonia. But as there are many island chains in that direction it was decided that the wave would probably be damped out by the shielding action of the islands, and no warning was given. This was justified by the events. At the expected time the water in Hilo bay began to rise and fall half a foot every 15 minutes, and continued to oscillate with slowly decreasing amplitude for two days. Subsequent reports revealed that the earthquake had occurred in the neighbourhood of the Solomon islands. Some tunami last for a few hours and the long cont nuance of others may be due to reflection from coasts near the epicentre, or waves may be broken up into many small ones by passing through groups of islands. Also, large bodies of water in bays will vibrate in their natural periods ('*seiche*' oscillations) long after being disturbed.

On 2 March 1933, a strong earthquake was recorded on Hawaii, indicating an epicentre 3,950 miles away. Warnings were issued of a wave to be expected in 8½ hours. The sampan fleet was moved

out to harbour anchorages, and stores were removed from wharves. The wave, which originated in the Tuscarora deep, arrived within 6 minutes of the predicted time. It had a range of $17\frac{1}{2}$ ft. in a series of ten-minute interval swings. Wide tracts of the sea bottom were bared and much damage resulted from the flooding of houses.

Submarine earthquakes have broken telegraph cables. In 1888, three cables connecting Australia with Java fractured simultaneously, and in the supposition that this sudden isolation indicated an act of war the Australian naval and military reserves were called out.

CORAL REEFS

The Pacific islands—often classified into two types, the 'high' volcanic and the 'low' coral—show a great development of living coral reefs (Fig. 2). A growing reef is a shallow-water tropical community of lime-secreting organisms, mainly corals with foraminifera and mollusca (animals), together with nullipores (plants) which latter have an important influence in cementing the whole deposit. The red seaweed *Lithothamnium* is particularly effective in cementing the outer surf and wave-battered edge of the reef, where it may build a 'lithothamnium ridge' up to a few feet high. The upward rate of growth of a vigorous reef is estimated to average $1\frac{1}{2}$ in. a year.

Reef-building corals do not grow at lower temperatures than 68°F.; those which will thrive at a certain temperature will barely survive a fall of only a few degrees. Speed and solidity of growth is greatly affected by light; in absence of light there is a slowing down of growth and weaker skeletons are formed. The animals are highly specialized for getting rid of mud, but rapid sedimentation will kill them. They cannot survive long exposure to the air, and they require water of normal marine salinity. The most favourable depth for healthy coral development is 15 ft.—i.e., most vigorous growth takes place immediately below the disturbed surface water. Growth does not occur below about 200 ft., probably because of the lack of light. The areal distribution of the living reefs is governed by the surface temperature of the ocean and they are not found towards the eastern borders, because of the cold sea currents and upwelling of cold water there.

Three main types of reef are recognized: fringing, barrier, and atoll. (Examples are shown in section on Fig. 14.)

The *fringing reef* is a flat extending outwards from the high-tide

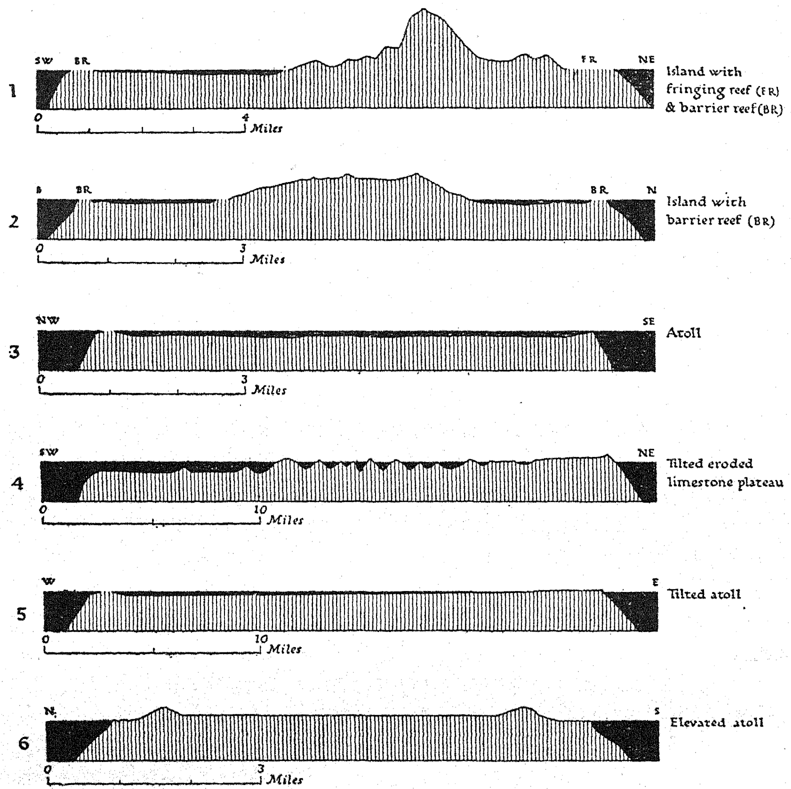


Fig. 14. Reef sections

Each section (1–6) represents a cross-section of an actual island with its reefs. The vertical scale has been exaggerated as follows: 1—Ngau (Fiji), twice; 2—Nairai (Fiji), 3 times; 3—Funafuti (Ellice islands), 3 times; 4—Vava'u cluster (Tonga), 7 times; 5—Uvea (Loyalty islands), 7 times; 6—Kambara (Fiji), 3 times. Section 1 is based on A. Agassiz, 'The Islands and Coral Reefs of Fiji', *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, vol. XXXIII, plate 13 (Cambridge, Mass., 1899). The others are based on R. A. Daly, *The Changing World of the Ice Age*, pp. 221, 251, 246, 246 and 245 (New Haven, 1935).

shore-line, with some scattered living coral colonies, but the region of active growth and of extensions is at the seaward edge and in the bordering shallows. Large blocks of coral rock with a thin blackened coating of algal growth (formerly colloquially known as 'niggerheads') may be found on the flat. These blocks, which are sometimes mistaken for volcanic rock, have been torn from the seaward edge and carried forward by great waves raised by tropical cyclones or, less

commonly, by volcanic eruptions and tunami. The reefs may be over a mile in width but they are commonly narrower. They are well developed in situations facing winds and currents which bring food and clear water conditions, whereas they are absent at river mouths where the falling sediment, diminished illumination, and brackish water are inimical to life. The extension of the reef into deep water can take place only with the building up of a talus bank to the level at which the corals can live.

The *barrier reef* (Plates 17, 20–2) is a similar flat, 20 to 1,000 ft. or more in width, roughly parallel to the shore, and separated from it by a lagoon (or 'moat' as Darwin called it), commonly from ½ mile to 10 miles or more in breadth. The most striking example, the Great Barrier Reef of Australia, is 600 miles long, approximately 50 miles off-shore, with a lagoon averaging 100 ft. in depth. The lagoons of some barrier reefs are so little occupied by an island or islands that the reefs are known as 'almost-atolls'.

An *atoll* (Plate 24) is an almost continuous reef, enclosing a flat-floored lagoon commonly 30 to 100 ft. deep, with a maximum depth of 300 ft. (Plate 25). Some atolls are nearly circular. The outward slopes to deep water are steep, commonly about 40°—one of 50° down to 2,000 ft. is known. The atolls are commonly separated by deep water. There are fifty in the Tuamotu islands with no inter-atoll depth less than 3,000 ft. and many exceeding 12,000 ft. Atolls may lie on ridges like chimney pots on a roof or on flats like barnacles. Drowned atoll reefs are known, e.g., the Penguin and Alexa banks north of Fiji. Some atolls may be coral cappings on submerged caldera rings; if so, they are exceptional.

Old fringing reefs now above high tide level are found on many islands. Those at elevations up to 15 ft. are common and they probably owe their situation to a recent fall of sea-level. Some higher

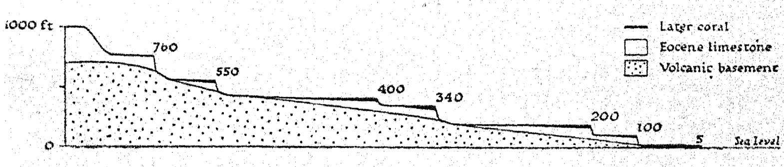


Fig. 15. Diagrammatic section, east side of 'Eua, Tonga

This section shows the terraces formed during the period of the fall of sea level. The figures give the heights of the terraces in feet above the present level. Based on J. E. Hoffmeister, 'Geology of Eua, Tonga', *Bernice P. Bishop Museum Bulletin*, no. 96 (Honolulu, 1932).

ones are due to elevation of islands. On the windward (eastern) side of 'Eua is a remarkable series of limestone platforms and cliffs at heights of 760, 550, 340, 200 and 100 ft. (Fig. 15). The terraces have been cut by marine erosion, but reefs grew at the outward edges of the 550 ft. and lower terraces. There is a 200-ft.-wide reef at 4 ft. above high tide, and a living fringing reef. On the western side of 'Eua at 400 ft. is what appears to be a raised barrier-reef flat separated from the higher land by a valley. A similar valley on Mangaia (the Taro flats), however, is believed to have been formed by erosion of the inner part of a fringing reef after elevation of the island. Many raised almost-atolls and atolls are known, at elevations up to 300 ft.—these include the important raised atoll of Nauru.

Origin of Barrier and Atoll Reefs

Charles Darwin considered these reefs to have been developed from fringing reefs as a consequence of gradual subsidence. With upward growth of the reef as the sea advances up the island slopes, and the recession of the shore line, a lagoon is formed between reef and island. Eventual submergence of the latter results in an atoll (Fig 16).

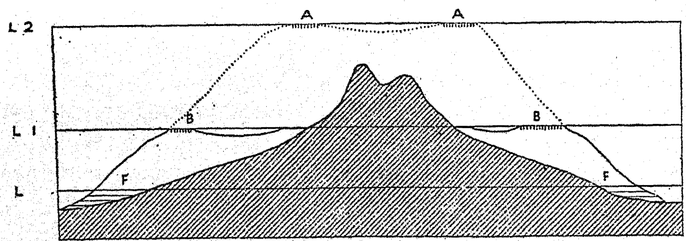
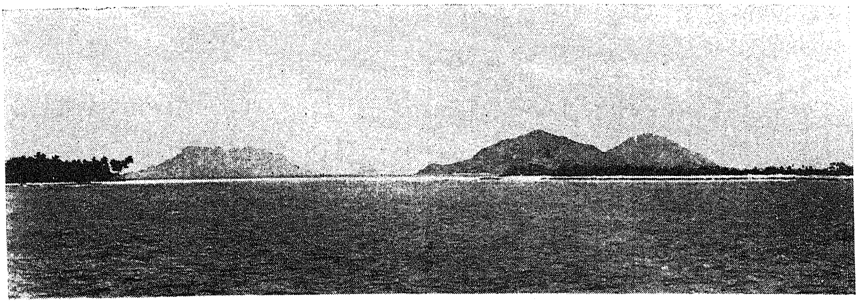
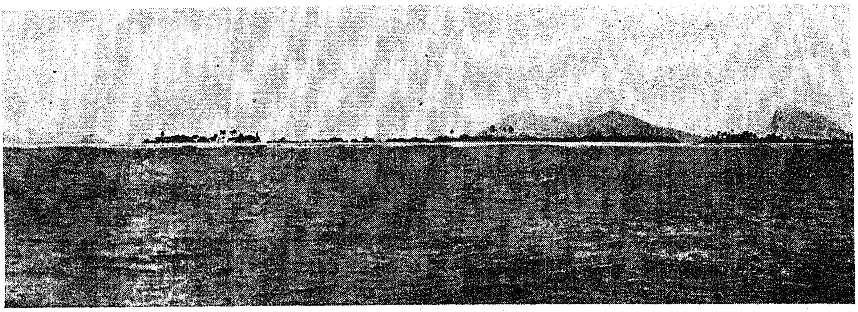


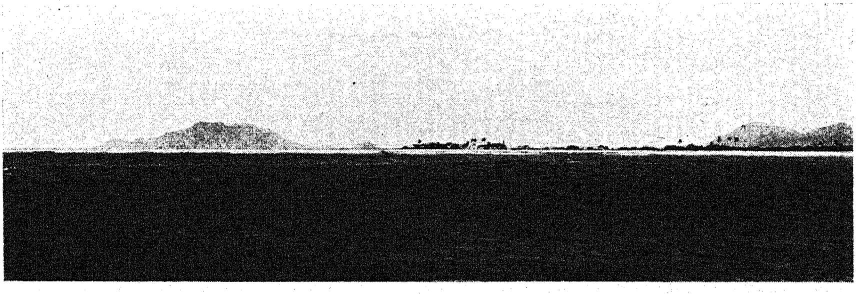
Fig. 16. Diagram illustrating Darwin's theory of the formation of coral islands by subsidence

The volcanic core of an island is shown in cross-section by the shaded area. L, L1 and L2 represent three stages in the rise of sea-level relative to the island. The accompanying upward growth of coral is shown by the unshaded area within the bounding lines. The shaded area F represents fringing reef; B represents barrier reef; and A the atoll rim. Based on R. A. Daly, *The Changing World of the Ice Age*, p. 254 (New Haven, 1935).

Evidence of the subsidence of the land behind the barrier reef is afforded by drowned river valleys, and further confirmation of subsidence has been sought by making borings into the reefs. If the coral is thicker than 200 ft. (the only range within which the corals can live), this would be evidence of subsidence. A boring into the







Plates 20, 21, 22. Views in the Mangareva group

Plate 20 (above) shows the islands of Akamaru (left), Mekiro (centre), and Aukena (right); they are seen through a gap in the eastern barrier reef. Plate 21 (middle) is another view looking westwards across an islet on the eastern reef to the gap between Akamaru and Aukena; mount Duff is seen on the right. Plate 22 (below) is a view looking across the same reef from a position further north. Akamaru and Mekiro show to the left and Aukena to the right.

Plate 23. A section of beach, Mangareva

This view shows the line of demarcation between the outer reef flat and the eroded face of the old land line at the base of a dam of loose coral rubble.

Funafuti atoll reef showed a thickness of 1,114 ft. of coral limestone, while a boring into the lagoon floor showed 282 ft.—in both cases no base to the coral rock was reached. It is considered that the lower part of the rock passed through in the deeper boring is probably coral talus, which accumulates on the seaward side of atolls. This leaves the evidence of subsidence inconclusive, although the presence of shallow-water fossils in position of growth in the talus supports the idea of subsidence. A boring into the Great Barrier Reef of Australia proves a recent subsidence of 600 ft. Reef coral was found down to 500 ft. and below that were quartz and foraminiferal sands. In Oahu (Hawaiian islands), coral limestone interbedded with lava and ash has been found in a well at 1,034 ft. below sea-level. Also, many atolls have outer submarine slopes steeper than those of talus or of normal volcanoes—a feature which is explained by Darwin's theory.

The lagoons within barrier and atoll reefs are shallow, and show little variation of depth compared with the great depth of the ocean around them (Fig. 17). Their floors, also, are remarkably flat. As the submergence postulated by Darwin is much greater than the depth of the lagoons, and coral growth on the lagoon floor is absent or insignificant, he supposed that deposition of material washed into the lagoons from outside and eroded from the inner reef margins, being distributed evenly over the floors by the agitation of the shallow water, kept pace with the sinking of the foundations and upgrowth of the reefs. This is a reasonable explanation. But some observers have thought that in some cases a greater rate of subsidence than of lagoon infilling might have occurred, and impressed by the absence of any deep 'moats' within the reefs, they have sought hypotheses which involve no great subsidence of foundations.

In the 'glacial control theory' developed by R. A. Daly, the growth of the present reefs is considered to have been initiated at the close of the last Ice Age, and on platforms produced under the special conditions which obtained during the cold periods. During the Quaternary Ice Age (or ages, for there is evidence in continental Europe, for example, of four cold periods separated by warmer 'inter-glacial' episodes) world temperatures were lowered—a fall of about 9° F. of the temperatures of the surface Pacific waters has been estimated. Glaciers existed then on the plateau of Mauna Kea (11,500 to 13,000 ft.) on the island of Hawaii. Another consequence of the Quaternary Ice Age was a lowering of sea-level owing to the abstraction of water by evaporation and its accumulation

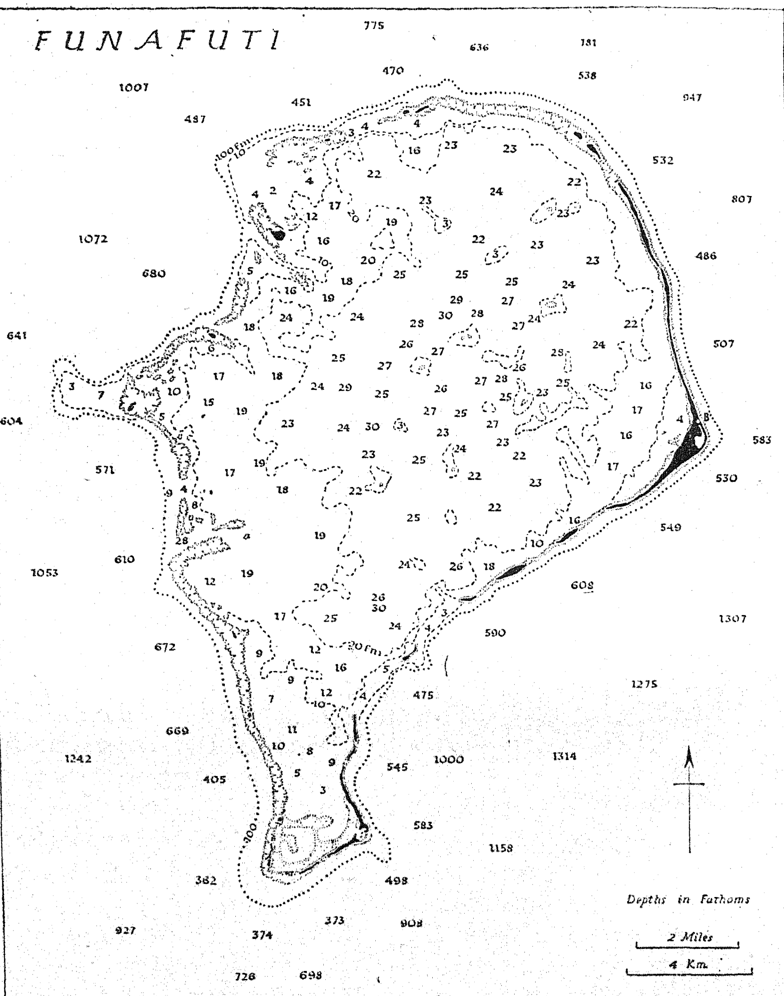


Fig. 17. Funafuti atoll

The figures indicate depths in fathoms. B (off the centre of the eastern rim) marks the site of the deepest bore-hole, which was sunk in 1897–8 to 1,114 ft. Based on: (1) Admiralty chart no. 2983; (2) R. A. Daly, *The Changing World of the Ice Age*, p. 251 (New Haven, 1935).

in the solid state to form glaciers on the lands. It is estimated that, owing to this cause, the sea-level fell by about 300 ft.

Under such conditions it is surmised that the corals would be

Plate 24. Tarawa atoll, Gilbert islands

An aerial photograph taken from a height of about 800 ft. Both sides of the atoll rim, covered with coconut palms, can be seen. Between them, showing lighter than the open sea, are the shallow waters of the lagoon.

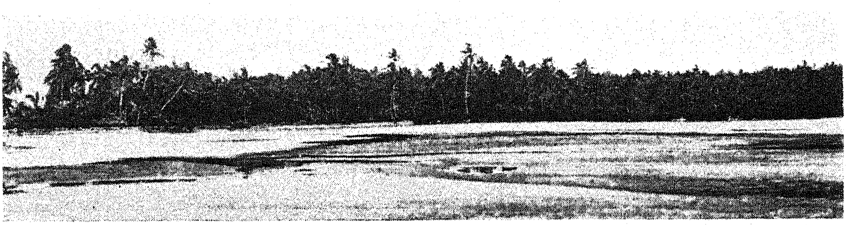


Plate 25. The lagoon flat, Butaritari

This photograph shows the eastern edge of the lagoon flat on the north side of the Keuea gap. It exemplifies the gently shelving muddy beach on the lagoon side of an atoll rim.

Plate 26. Southern Kauai, Hawaiian islands view shows dissection of volcanic highlands.

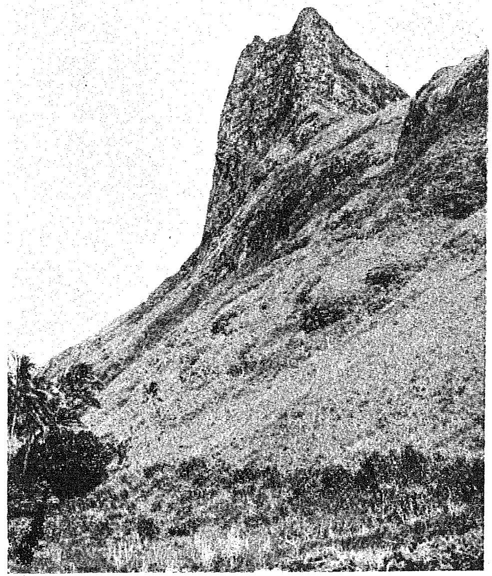


Plate 27. Mount Duff, Mangareva
This view is taken from the summit of the plateau on the south side of the peak. The mountain is a remnant of harder material left after considerable erosion of the rest of the island.

and that in the absence of a growing reef the destructive action of the waves would have full play in attacking the new shore line and would thus erode a shore platform. With the return of warmer conditions, corals spread on these platforms and, with the rising sea-level produced by the returning water from the melting glaciers, grew upward and outward, to form the present barrier reefs and atolls. On this theory the thickness of the reefs is not greater than about 300 ft.—excepting where the living coral has grown on coral-rock talus. This theory is similar to Darwin's in that the coral upgrowth is conditioned by a rising shore level and accompanied by drowning of valleys of the coastal lands behind the barrier reefs. But the amount of relative subsidence postulated is restricted, and the foundations of the islands are considered to be stable.

Critics of the glacial control theory draw attention to the widespread evidence of independent vertical movements and tilting of the islands (i.e., want of stability) as given by the reefs now above sea-level, and to the evidence that some islands afford of submergences much greater than 300 ft. The rock bottoms in the embayments of many reef-encircled volcanic islands are believed to be of much greater depth and width than can be accounted for by the low-level erosion of still-standing islands during the glacial epochs. It is to be noted also that there is a considerable variation in lagoon depths. The lagoon in the large almost-atoll of the Exploring isles in eastern Fiji reaches a depth of 90 fathoms, whereas that of Christmas island, 15 miles across, is only 4 fathoms deep. However, most of such variations can easily be accounted for by varying conditions of deposition in the lagoons, and the absence of very deep lagoons remains a striking feature. An acceptable theory must account for the general rule; reasons can generally be found for exceptions.

A further consideration is of considerable importance. An island unprotected by reefs—the situation postulated in glacial times—must suffer erosion by the waves which cut into the land like a horizontal saw, producing at sea-level a rock platform which is bounded by steep cliffs. This condition is illustrated in Fig. 18, sector B. With rise of sea-level and renewed coral growth the valleys are inundated and the lagoon is formed behind the up-growing reef as shown in sector C. Cliff formation ceases, but one would expect plunging cliffs, being relics from those formed by the erosion of the reefless island, as in sector B. The reef-encircled islands of the main area of the coral seas are, however, prevailingly non-cliffed—a circum-

stance which falls in better with Darwin's theory, in which the island shores are considered to be those of a progressively drowned land which was continuously protected from marine erosion by an off-

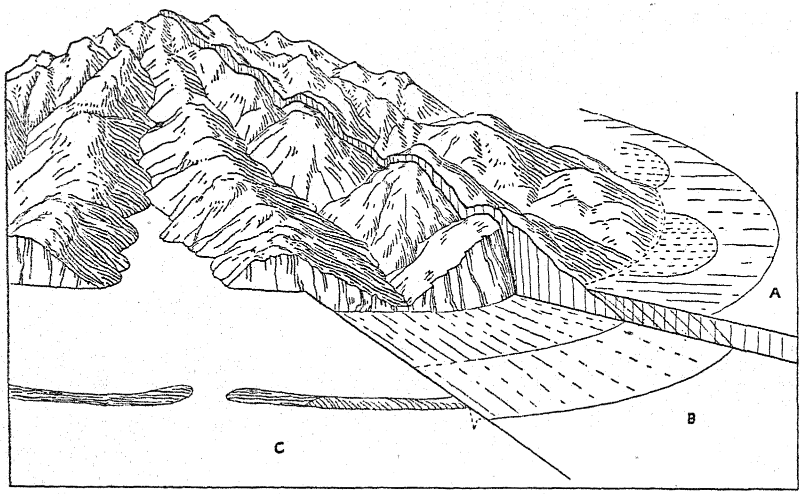


Fig. 18. Sector diagram showing the effects of a long period of low-level abrasion on a still-standing island

Sector A shows the island with fringing reef. B shows in its wave-cut platform and sea-cliffs the effects of marine erosion exposed as a result of a fall of sea-level. C shows the effects of a subsequent rise in sea-level with the formation of a barrier reef backed by a plunging cliff. Based on W. M. Davis, *The Coral Reef Problem*, p. 211 (New York, 1928).

shore living barrier reef. Cliffed islands are common, however, on the cold margins of the coral area (in the Hawaiian islands, for example) and over these relatively small areas the sequence of events postulated by the glacial control theory may have obtained.

The rarity of cliffed islands in the coral seas also bears pointedly on the suggestion that barrier reefs have not been built up on subsiding foundations, chiefly by corals, as Darwin proposed; but have been built up on stationary foundations, chiefly by nullipores, which can live in deep and cold water, and that corals have only added a shallow crown to the great nullipore structures. If this were so, the originally conical islands, 'still-standing' and unprotected while the nullipores were building up their deep banks, would to-day have well-cliffed, non-embayed shores, whereas nearly all barrier-reef islands have well-embayed, non-cliffed shores.

It is clear that the histories of the reef islands have been various.

Fig. 19 illustrates the development of the Exploring isles and their small atolls, as imagined by W. M. Davis. The central portions of the sectors represent the larger islands, the outer ones the smaller islands. Sector A shows the initial forms due to volcanic eruption. Sector B shows the forms of well advanced erosion and partial submergence until only mountain-top islets survive with an almost-atoll reef, and atolls outside (sector C). Sector D represents the forms which would be shown by uplift without erosion, and sector E the forms actually realized when, elevation having ceased, the limestone area is for the most part stripped from the volcanic mounts and reduced to low relief. Sector F shows the forms of to-day, after the limestone area is submerged beneath the lagoon of a new barrier reef, above which rise the little modified volcanic mounts with their residual limestone patches.

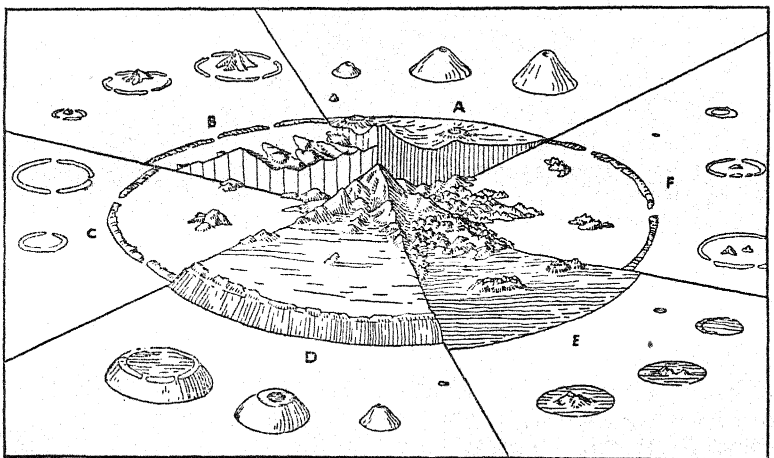


Fig. 19. Sector diagram illustrating the development of the Exploring isles, Fiji

Sectors A, B and C show the effects of various stages in subsidence. D shows subsequent elevation. E shows marine erosion of the platforms, and F the effect of later subsidence. Based on W. M. Davis, *The Coral Reef Problem*, p. 211 (New York, 1928).

Some of the reef-encircled islands have been deeply eroded—a process which takes a long time and involves the disappearance of great volumes of rock detritus. Such islands may have delta and coastal flats built of sediment delivered by rivers, but these deposits represent only a fraction (estimates of 1/50th and 1/100th have been made for some cases) of the material which has been removed. With

active delivery of sediment to coasts, coral growth is smothered, and the disposal of the detritus in such barrier reef islands presents a problem. It has been suggested that in the earlier stages of the erosion of these islands they were reefless, and that the sediment was distributed to off-shore waters by wave action; with subsidence the detritus was deposited in the drowned valley bays, whilst the barrier reefs grew upward on the banks of detritus off-shore.

After a period of scepticism and strong criticism, Darwin's theory has come into favour again, as affording the most valuable clue to the general solution of the reef problem, which is an extremely complex one.

The varied histories, ages, and situations of the reefs show that no one hypothesis can be adopted for all cases—each reef calls for individual study. Before convincing solutions to the problems of the origins of the different reefs can be found, more information must be obtained regarding the thicknesses and natures of the reef limestones, and of the forms of the volcanic foundations upon which they rest.

THE SCULPTURING OF VOLCANIC ISLANDS

The original forms of the volcanic islands were due to accumulation of lava and ash around centres of eruption—they were relatively even and smooth, conical and dome-shaped slopes, at from 5° to 30°. The craters and calderas were central, circular, or elliptical areas bounded by steep cliffs. In some cases earth movements along steep fault-planes have abruptly lowered parts of the accumulations, leaving a scarp where sections have foundered beneath the waves. All these features are due to accumulation, explosion,

Fig. 20. Sub-mature dissection of a volcanic island
The island was initially a basalt dome. Based on C. A. Cotton, *Geomorphology*, p. 372 (3rd edition, Christchurch, 1943).

and earth movements. With the cessation of volcanic activity, the slow action of the forces of erosion proceeds to modify the original land forms (Plates 26–7). In time all traces of the original surfaces are lost, and the final stages—given a long enough 'still-stand' of shore level—are those of a low island and, eventually, a submarine bank.

The process starts with the development of streams in the lower regions of the volcanic pile, and these form valleys radiating outward from the centre like the spokes of a wheel. With the continued widening of the valleys, ridges are left between them in the upper parts where the valleys are closer together, whilst the original slopes may still be preserved at lower levels (Fig. 20). Eventually, all the original slopes disappear, and the radial valleys and the outward dips of the lavas and ash beds revealed in the valley sides remain as witness of the site of the now degraded volcano.

Caldera walls become reduced in time and a valley cutting backwards into the dome may reach and drain the central depression. The whole centre of the main volcano in Tahiti is replaced by the

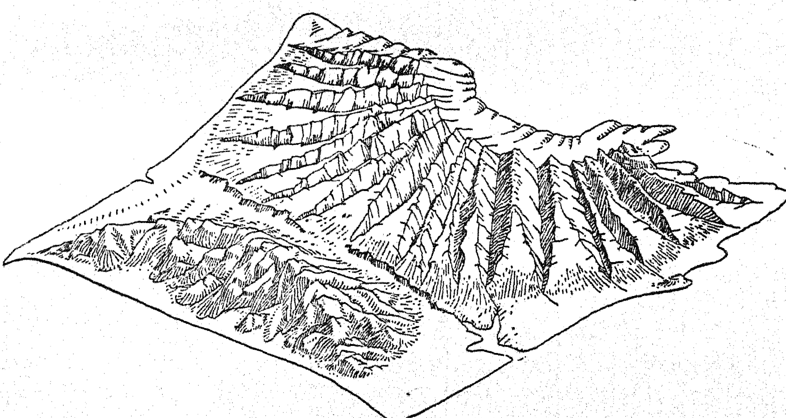


Fig. 21. Bird's-eye diagram of Oahu

The diagram shows contrasts in the dissection of the leeward and windward sides of the island. Based on W. M. Davis, *The Coral Reef Problem*, p. 170 (New York, 1928).

Papenoo valley, which is surrounded by a ring of high residual peaks. It is difficult in such a case to determine, after such prolonged erosion, whether the central area is primarily the site of an original caldera, or whether its surface has been largely lowered as a consequence of headward valley erosion. Great hollows presumed

to have been eroded in the centres of volcanic mountains are termed 'erosion calderas' in contradistinction to the original volcanic crater caldera.

The stages of erosion may vary greatly on the sides of a dome if there is a difference in rainfall, as in Hawaii. The rainy windward side may reach an advanced stage of dissection and acquire a very rugged appearance, whilst the leeward side retains much of its smooth dome-like form (Fig. 21). Apart from this consideration it may be said that the more dissected an island is, the longer the period which has elapsed since the cessation of volcanic activity.

The development of land forms in volcanic islands may be illustrated from the island of Oahu (Hawaii). The original island was a volcanic doublet (Fig. 22), the younger and larger cone lying to

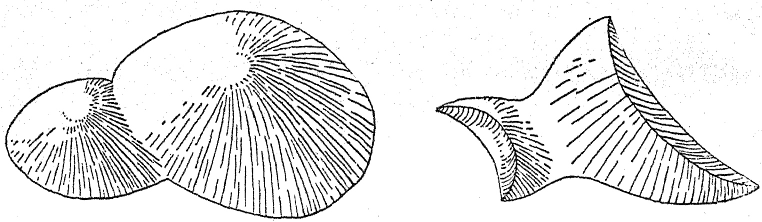


Fig. 22. Diagram illustrating the structural origin of Oahu

On the left is shown the initial form of the volcanic doublet; on the right is the residual doublet after the loss of part of each volcano. Based on W. M. Davis, 'The island of Oahu', *Journal of Geography*, vol. XXII, p. 354. (Chicago, 1923).

the east. The present island differs from the original through the loss of nearly half the western cone and more than half of the eastern one (probably by down-faulting), and by the erosion of the residual half cones into bold mountain forms (Fig. 21). The older western one, the Kaala range, is much more dissected than the younger eastern one, the Koolau range. Several limestone coastal plains, now partly overwashed by volcanic detritus from the mountains, occupy the wide valleys of the western coast; a smaller one lies in the northern re-entrant angle between the two cones; and the largest stretches all along the southern coast. The largest varies in width from several hundred feet to two to three miles, and along its landward boundary lie limestone cliffs denoting a former shore line. Also there is a coastal plain almost wholly composed of volcanic detritus at the base of the great cliff, the Pali, in which the broken-down younger cone faces the mid-eastern coast. The cliffs of the

younger cone, being on the windward side of the island, receive a heavy rainfall and are clothed with verdure, while the deeply eroded seaward slopes of the older cone on the leeward side of the island are relatively dry and have scanty vegetation.†

Cliffs are formed where marine erosion, in the absence of a coral reef, is active (Fig. 23). Their presence at the shores of a lagoon

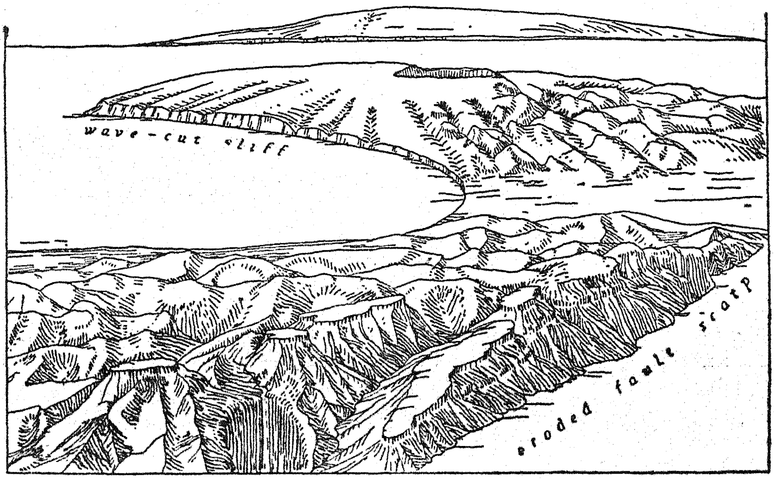


Fig. 23. Maturely dissected lava domes

The diagram shows cliffs formed when bounding reefs are absent. Based on A. K. Lobeck, *Geomorphology*, p. 676 (New York, 1939).

behind a barrier reef may be explained on the hypothesis that they were formed before the reef was in being, and when the shore level was lower. Flat lowland at the borders of islands may represent uplifted sea floor, as in the case of Oahu cited above, or it may be built of land-derived sediment. In Tahiti submergence produced drowned-valley embayments (Fig. 24), all of which are now filled with delta plains, save for some small unfilled bays where the streams in the valleys at their heads are short and small. These level plains have advanced far enough outside the former bays to become laterally confluent in a narrow alluvial lowland (built up from volcanic detritus and up to 1,000 ft. broad) around much of the coast of Tahiti. Behind these coastal plains with their rich soil are cliffs cut out of

† For another interpretation of the geological history of Oahu, see H. T. Stearns and K. N. Vaksvik, 'Geology and Ground-water Resources of the Island of Oahu', *Division of Hydrography, Bulletin*, I (Honolulu, 1935).

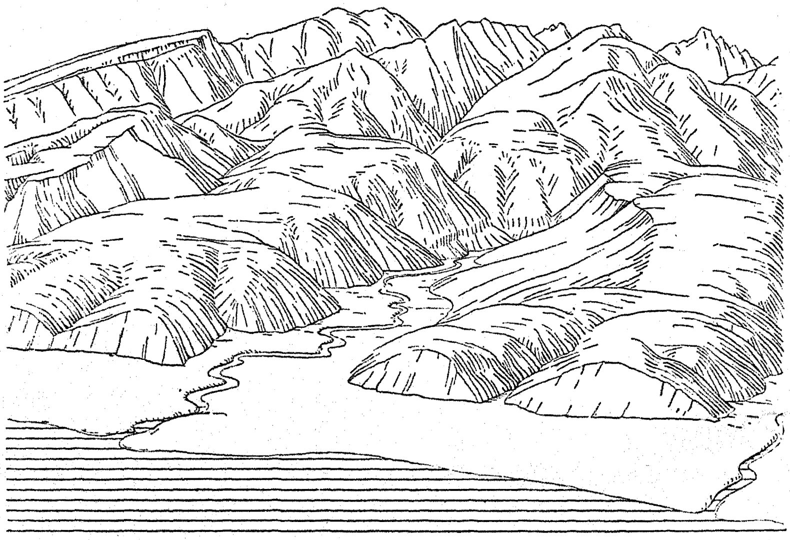


Fig. 24. Embayed and delta-filled valley between two spurs, north coast of Tahiti. Based on W. M. Davis, *The Coral Reef Problem*, p. 255 (New York, 1928).

volcanic rocks, as much as 500 ft. high. These cliffs are now beyond the reach of the waves and have weathered into steep slopes masked by clay and rubble.

DEPOSITS ON THE FLOOR OF THE PACIFIC

In shallow water adjoining the land, material accumulating on the sea floor is sand and mud derived from the land masses—the so-called terrigenous deposits. The material becomes finer in particle size with increasing distance from the shore. Water charged with sediment in suspension is heavier than clear water, and it slides down the continental slopes beneath the stiller upper waters for tens of miles before all its load is dropped; thus the muds often extend 200 miles from the shore.

The main area of the Pacific is out of reach of this material, and the deposits are of two main types—the ooze and the red clay. The oozes are composed of the skeletons of tiny organisms (plankton) which live mostly near to the surface and which on death slowly rain down towards the ocean floor. In the globigerina and pteropod oozes the skeletons are of calcium carbonate; in the diatoms and radiolaria they are of silica. The distribution of the various oozes (Fig. 25) is obviously governed by the nature of the dominant

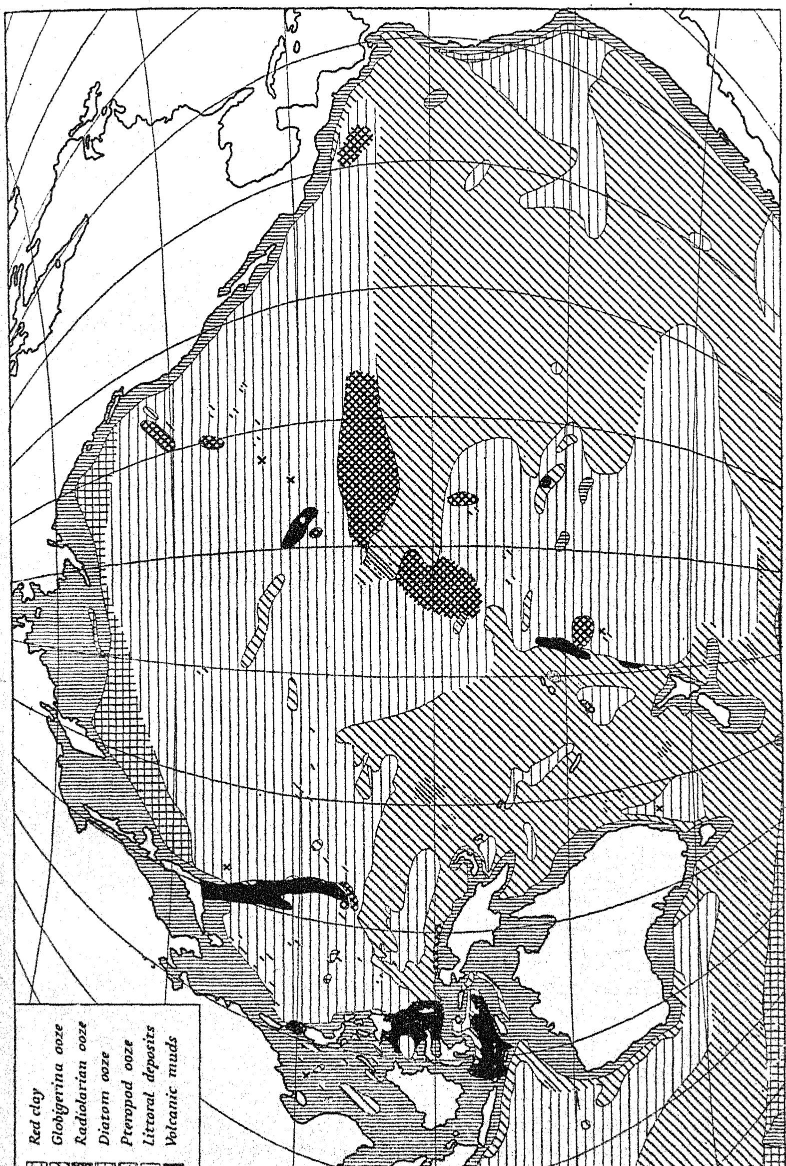


Fig. 25. Distribution of submarine deposits in the Pacific basin
Based on G. Schott, *Geographie des indischen und stillen Ozeans*, Tafel V (Hamburg, 1935).

planktonic life in the waters above them; but it is also controlled by the depth. In the deep water calcium carbonate is more soluble than silica, so that deeper water favours the accumulation of siliceous ooze. Much work has been done on the distribution of the diatoms in the southern seas by whale-hunting interests. The whales live on prawns which in turn live on diatoms. Diatoms are plants which live only in the uppermost 150 ft. where there is light.

In the deepest waters both calcareous and siliceous skeletons are absent—having been dissolved on descent—and the deposit is a fine 'red clay' made up of altered volcanic and meteoritic dust, with no organic remains save the resistant teeth of sharks and bone of whales. Thus the *Nero* in 1899, when laying the telegraph cable from the United States to Japan, found globigerina ooze at depths down to 2,200 fathoms, and in deeper water, red clay was found. This deposit contains manganese, giving it a chocolate colour, and manganese nodules have been dredged from it in great numbers. Spherules of nickel-iron (cosmic meteoritic material) are also found.

The deep-sea deposits grow slowly. For the oozes the estimate is from about 1 in. in 2,000 to 6,000 years, whilst the rate for the red clay must be slower. With the Piggot core-sampling gun it is possible to bring up cores up to 10 ft. long. The gun is a long brass tube with a weight on the top and a cartridge inside (Plates 28–9). On reaching the bottom the cartridge is fired and the tube driven far into the deposits. A core of red clay has thus been obtained 220 miles west-south-west of San Diego, California.

If the Pacific ocean has existed since the birth of the earth (say, 2,000 million years ago) it has been estimated that the accumulated and compacted deep-sea sediments may be about 4 miles thick. There is good hope that in the future it will be possible to determine the thickness of the deposits by using seismic methods to measure the velocities of artificial shock waves through the sea floor. The velocity will be greater in the rocks beneath the deposits, and it should be possible to discover the position of the base of the latter.

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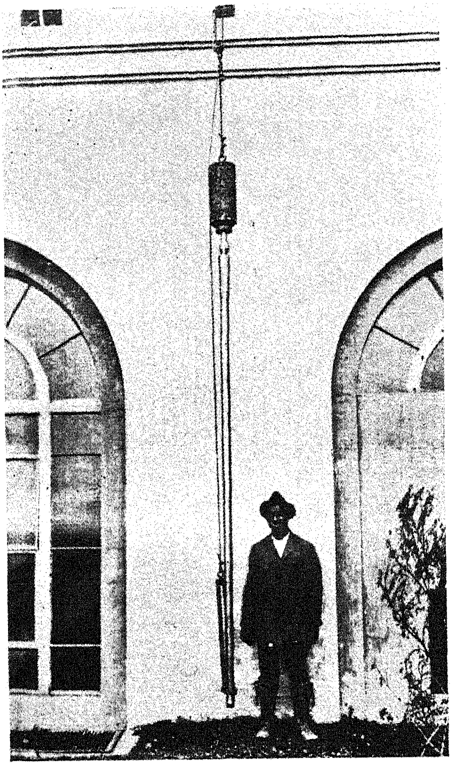

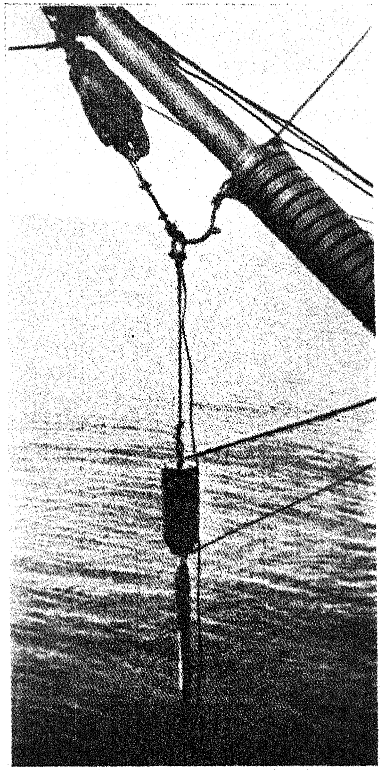

Plates 28–9. Piggott core-sounding apparatus

Plate 28 shows the apparatus assembled ready for lowering. Plate 29 shows it suspended on the ship's sounding cable and about to be lowered; the safety pin is being pulled by means of a lanyard.

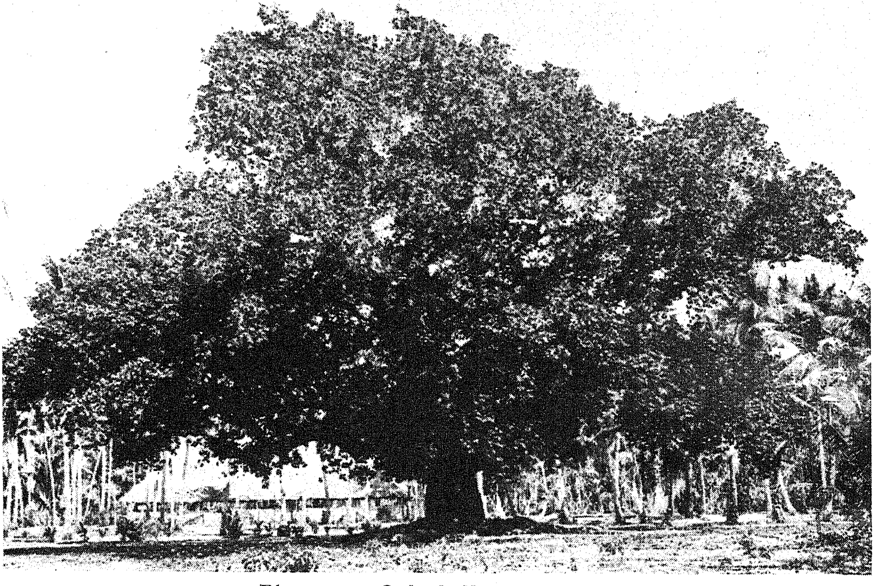

Plate 30. *Calophyllum inophyllum*
A common tree of the sea coast throughout the Pacific islands. It is also known as native almond or *tamanu*.

Plate 31. Beach vegetation, Nauru

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Chapter III

CLIMATE

Pressure and Wind: Temperature: Humidity: Visibility and Fog: Rainfall: Bibliographical Note: Climatic Tables

Since the Pacific ocean is divided by the equator, the climatic elements are reproduced more or less symmetrically in either hemisphere. The axis of symmetry in any particular month is the equatorial belt of low pressure or 'doldrums', the position of which is described below. It is a region of light variable winds, preponderantly easterly in direction, towards which blow the trade winds, diminishing in force and reliability as they approach the trough of lowest pressure where the constantly incoming air escapes upwards. The doldrum

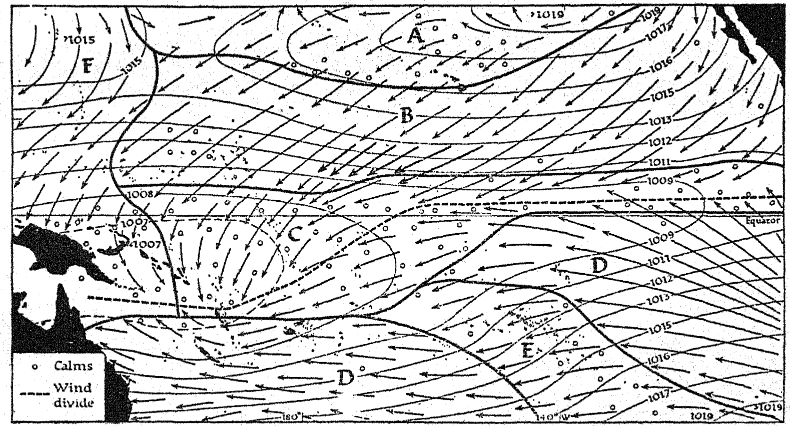

Fig. 26. Pressure, winds and wind belts: January–February

The letters refer to the following regions: A, variables of the tropic of Cancer; B, the north-east trades; C, the doldrums; D, the south-east trades; E, the variables of the tropic of Capricorn; F, the monsoons. The figures show pressure in millibars. Based on G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, p. 90 (Berlin, 1938).

belt migrates north in the northern summer to a limiting position about 5° N in July and August, whence it retreats to the other extreme in January and February. At this season it is in general still north

of the equator to the east of long. 160° W (Christmas island), but bulges as far as 10° or 12° S near the Ellice islands and the Solomon islands.

The source regions of the trade winds are the high-pressure belts lying about 30° N and S. As a result of a procession of anti-cyclones moving eastwards, the mean pressure is generally high right across the ocean in these latitudes. It is highest towards the eastern side of the ocean in each hemisphere where the mean isobaric map shows oval highs in the centre of which pressure exceeds 1020 mb. The mean position of these high pressure areas changes very little with the seasons; the details can be seen from Figs. 26 and 27.

The trade winds blow with great regularity from east-north-east on the north side of the doldrums, and from east-south-east on the

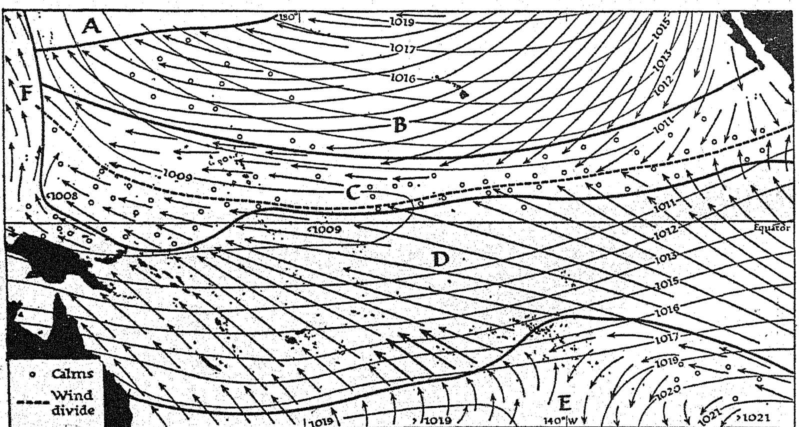

Fig. 27. Pressure, winds and wind belts: July–August

The figures show pressure in millibars. Key to regions and source as for Fig. 26.

south side. They prevail over the whole of the width of the ocean except for a narrow belt on the east and a much wider belt on the west.

On the east side near the American coast, the winds, circulating round the anticyclones described above, blow parallel with the coast, from the south off South America and from the north off California. The south winds extend across the equator and prevail

at Cocos island from April to October and at the Galápagos from March to January (the *garúa* season—vol. II, p. 25).

Such, in broad outline, is the scheme of winds in the mid-Pacific and in the Eastern Pacific between 30° N and 30° S. It is simple and symmetrical, but west of about 150° E the symmetry of winds and other climatic elements is destroyed by the influence of the great land mass of Asia with its powerful monsoon, which strongly affects the climate to a distance of over 1,000 miles from the mainland. Because the north Pacific is bordered by the two largest land masses

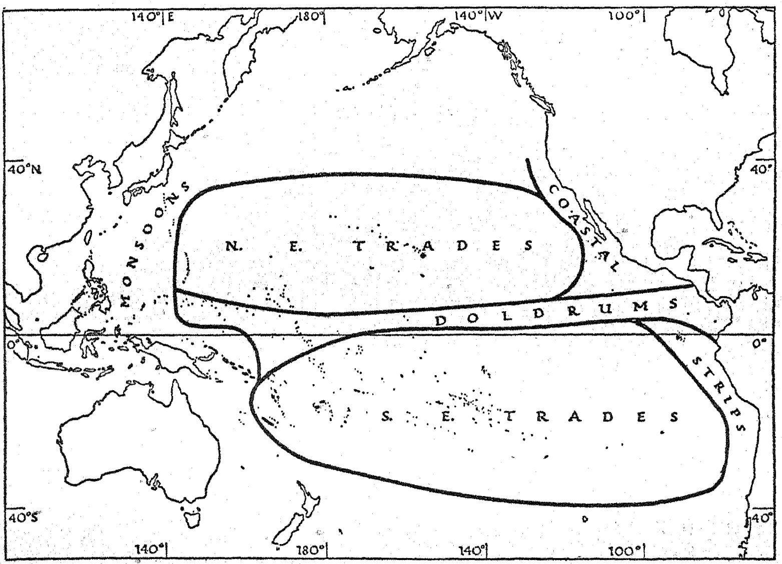

Fig. 28. Climatic regions of the inter-tropical Pacific

The regions are defined according to their prevailing winds. The winds of the 'coastal strips' blow parallel with the American coasts. Based on various sources.

of the world its seasonal contrasts are more pronounced than those of the wide south Pacific, with its relatively small and discontinuous flanking land masses.

The inter-tropical Pacific can thus be divided into regions of prevailing winds (Fig. 28). Since the nature and source of the air currents is the chief factor in determining other weather phenomena, these wind regions become climatic regions, the chief characters of which may be tabulated, in very general terms, as follows :

Region	Prevailing Wind	Rainfall	Temperature	Remarks
North-east trades	ENE; strongest in winter	50–100 in.; all year. Heaviest precipitation on windward side of high land	66°–78° F.	High proportion of sunshine
Doldrums	Easterly; light and variable	100–150 in.; all year, autumn maximum	78°–82° F.	Muggy; night thunderstorms in rainy season
South-east trades	ESE; strongest in winter	50–150 in.; all year, driest in winter; precipitation greatly affected by relief	60°–80° F.	High proportion of sunshine
Monsoon	Reversed with seasons: light and variable at change-over	100–150 in.; seasonal, summer maximum; highest on windward side of land	62°–84° F. considerable range off Japan	Liable to typhoons, thunderstorms in rainy season
American coastal strip	Northerly (northern hemisphere); southerly (southern hemisphere)	60 in.; rather dry, especially in southern hemisphere	60°–78° F.	Tendency to cloud and fog in shore, especially outside the tropics.

PRESSURE AND WIND

With the exception of a small area in the vicinity of the Asiatic coast from Shanghai to the island of Kyushu, the Pacific between 30° N and 30° S is seldom affected by temperate depressions, and within this belt the pressure is remarkably uniform. The highest pressure is 1026 mb. (near Hawaii) and the lowest 1006 mb. (near New Guinea). The yearly range at any one place, due to the seasonal migration of the pressure systems, nowhere exceeds 10 mb. and the day-to-day variation is so slight as to be negligible. Under these conditions, the diurnal variation of pressure is clearly recognizable and is remarkably regular and reliable. It reaches maxima at 1000 hr. and 2200 hr. and minima at 0400 hr. and 1600 hr., the amplitude being about 3 mb. This regular rise and fall twice daily is only interrupted by the rare introduction of a deep low pressure (tropical cyclone) whose approach may be detected in single observer forecasting by the failure of the daily maximum to attain that of the

previous maximum. Any noteworthy disturbance of the settled course of the barometer changes should therefore be regarded seriously, as a possible precursor of development of a typhoon. During a typhoon the barometer descends very low, perhaps 50 mb. (fifteen times the normal diurnal variation).

The broad features of pressure and wind systems have already been described. Details of the direction and reliability of the winds for January, April, July and October are given in Figs. 29–32; they are described below.

The Doldrum Belt

It will be noticed that in the Eastern Pacific the trade winds are decidedly north-east and south-east; their convergence is thus well marked and the area of convergence is wide. But in the central Pacific and the Western Pacific their direction is almost from east to west, the two air streams are almost parallel in direction and the zone of convergence is narrow and ill-defined. East of long. 165°W, the doldrum belt is north of the equator throughout the year and is situated in lat. 5° to 10° N. It is well defined from June to January, but the typical conditions occur only irregularly in the other four months. In mid-Pacific and in the Western Pacific, from 165° W to 155° E, it shows a tendency to split and spread; it is less clearly defined than in the eastern part. The line of convergence is commonly south of the equator and lies between the Phoenix group and the Solomons, especially from December to May. Variable light winds, often from west or south, accompanied by storms, are characteristic of the Cook islands and Samoa from December to March. From June to October, however, the line of convergence is usually to the north of the equator in the neighbourhood of the Caroline islands and Guam. Though the wind is typically light and flat calms are frequent, the doldrums are liable to violent squalls, usually of short duration, accompanied by thunder, lightning, heavy rain, and, not infrequently, waterspouts. The storms mostly occur at night. There is much heavy cloud and rain.

Trade Winds

It can be seen from Figs. 29–32 that the trades of the northern hemisphere are more constant in direction than those of the southern. In the middle and eastern parts of the north Pacific 60% to 90% of winds follow the prevailing direction; in the southern Pacific

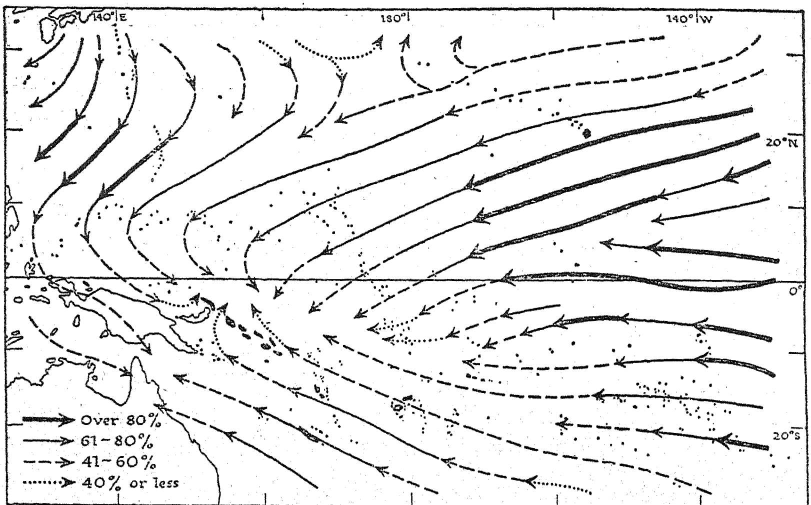

Fig. 29. Average surface wind-drift: January

Figs. 29–32 show the percentages of winds which follow the prevailing direction. They are based on the U.S. Hydrographic Office, 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), pp. 11-15.

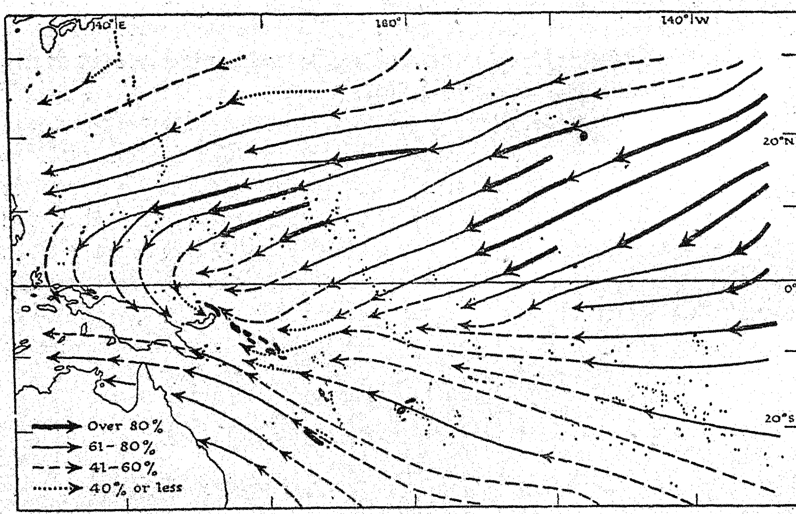

Fig. 30. Average surface wind-drift: April

For explanation and source see Fig. 29.

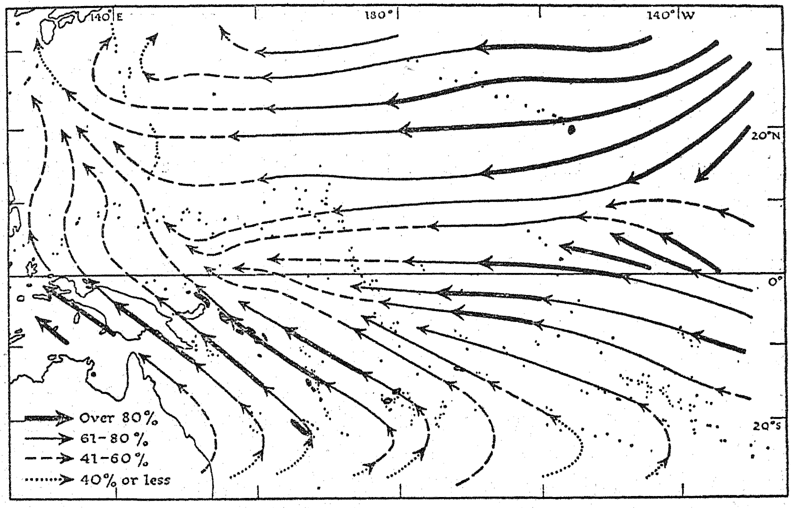

Fig. 31. Average surface wind-drift: July

For explanation and source see Fig. 29.

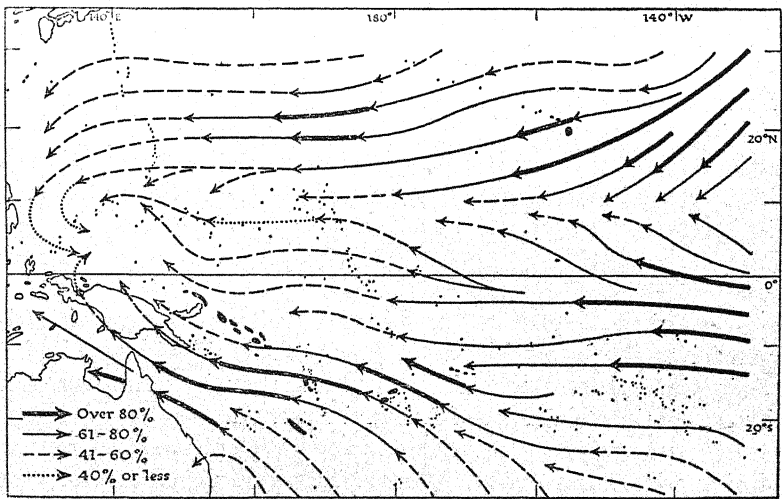

Fig. 32. Average surface wind-drift: October

For explanation and source see Fig. 29.

the constancy is of the order of 50% to 70%, the reliability being highest in mid-winter (July and August).

Percentage frequencies for some island stations are given in Table I (p. 90). Remarkable as the constancy of the trade winds is at these stations, it is even more so over the open sea where the air flow is uninterrupted and no land-and-sea breeze effects occur as they do on islands.

The mean force of the trade winds is shown in Figs. 33–6. Both trade winds reach their greatest force and constancy during their respective winters, the north-east trade principally in the middle third of the whole region (that is, east of the Marshall islands) the south-east trade mostly in the eastern third, roughly from the Marquesas eastwards, and also in the neighbourhood of the Cook islands. They decrease in force both equatorwards, towards the doldrums, and, polewards, towards the high pressure ridges about lats. 30° N and 30° S. Winds are slightly stronger in the northern hemisphere than in the southern. Owing to retardation by friction the winds recorded at island stations are about 3 knots less than over the open sea.

Table II (p. 95) shows that from half to two-thirds of winds are between 4 and 14 knots and that winds exceeding 28 knots (force 7 and over on the Beaufort scale) are rare.

The weather of the trade winds is brisk and refreshing. Coming from higher latitudes the winds are relatively cool and the cooling effect is heightened by their low relative humidity and the constant fanning action which promotes evaporation from the skin. Near the high-pressure centres the sky is often cloudless, and elsewhere it is only partly covered with broken cumulus. Thus there is a high proportion of bright sunshine which adds to the sensation of invigoration.

Region of Monsoon Winds

West of the line shown on Fig. 28, which runs approximately parallel to the larger islands of Japan, the Philippines and New Guinea and about 1,000 miles out to sea, the winds are controlled by the continental masses of Asia and Australia.

In both hemispheres the trade winds are strengthened and diverted during winter and almost reversed in summer. The south-west monsoons of the Western Pacific are neither so strong nor so reliable as those of the Indian ocean, but the north-east monsoons are stronger than those of the Indian ocean.

Winds are strongest and most reliable at the height of each monsoon, from July to August and from December to February. At the change-over season, calms and variable winds are frequent and the region becomes part of the doldrums. It is partly for this reason that the doldrum belt of calms is so wide and variable in position in the Western Pacific.

The 'Horse Latitude' High Pressure Belts

The frequent passage of anticyclones across the ocean in latitudes about 30° N and 30° S results in a ridge of high mean pressure that, in effect, forms the wind divide between the trade winds and the westerly circulation. The trade winds weaken as these latitudes are approached and winds become light and variable in direction. The high pressure results in a descending motion of the air and therefore in dryness of the air and absence of cloud.

The American Coastal Strip

Off these coasts the prevailing winds are directed towards the doldrums that lie roughly on the equator in February and off Mexico in August. A cold current flows from the south up the coast of Peru and swings westwards where the coast changes direction off cape Blanco in Ecuador. A similar current off California has less power and does not make the sea unduly cold south of the tropic of Cancer. Low cloud and fog may occur with on shore winds off Peru.

The Westerlies

The most southerly islands experience westerly winds in winter; at Rapa (27° S) west winds prevail from May to September and at Norfolk (29° S) from June to August. Polewards from the horse latitudes in the north Pacific the prevailing winds are westerly or south-westerly, becoming stronger with increasing latitude. Where these winds meet polar or Arctic air blowing from the cold regions of north-east Asia and Alaska cyclonic storms are generated. Winter is therefore the stormy season. The average frequency of these storms in winter is shown in Fig. 37; it is highest along the line of Japan, the Kurile and the Aleutian islands, which appears to represent the mean position of the Polar Front in the north Pacific. Only the western end of this storm belt, off Japan, concerns the present Handbook, but it causes a rapid increase in frequency of gales to the north of 30° N (Table III (p. 96)—Tatoosh island figures).

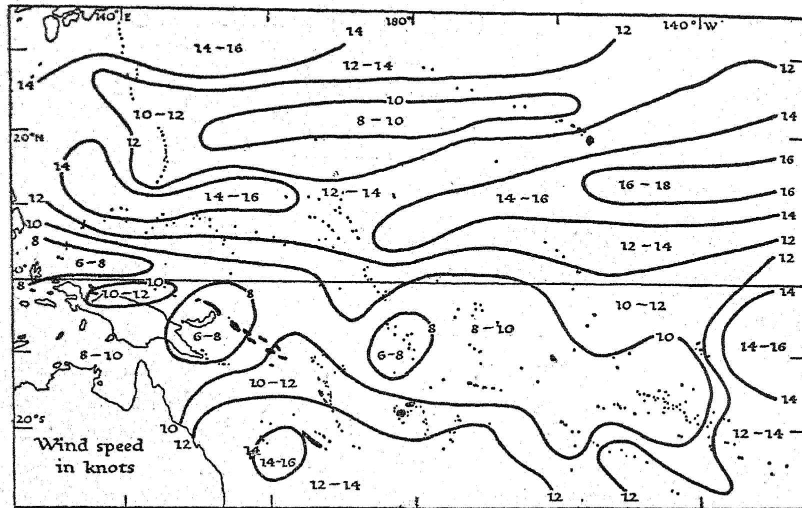

Fig. 33. Average surface wind speed in knots: December to February

The values shown in Figs. 33–6 are computed by conversion from the average Beaufort numbers in ships' observations. Figs. 33–6 are based on the U.S. Hydrographic Office, 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184, pp. 19–20.

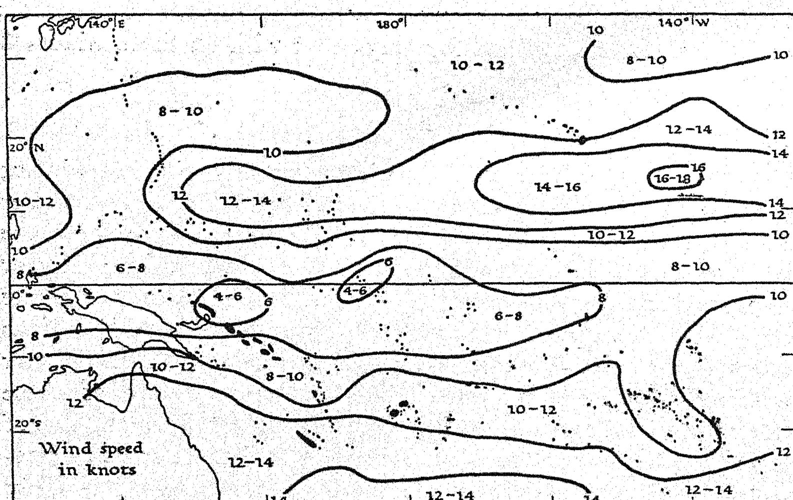

Fig. 34. Average surface wind speed in knots: March to May

For explanation and source see Fig. 33.

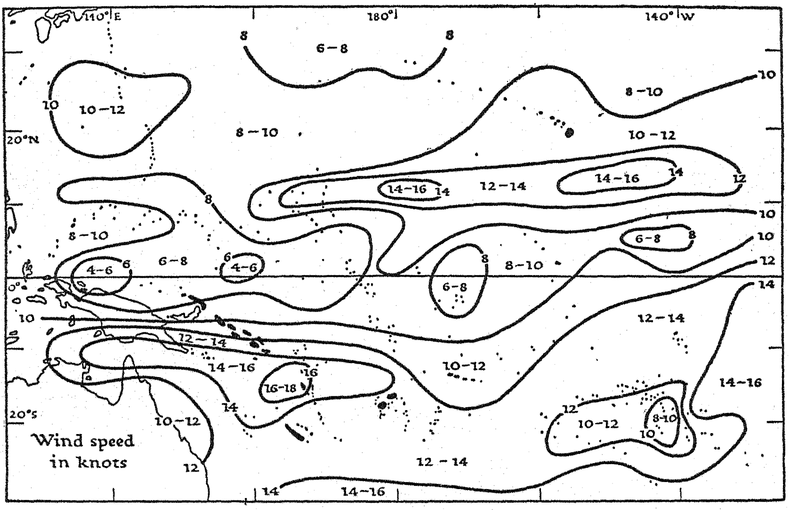

Fig. 35. Average surface wind speed in knots: June to August

For explanation and source see Fig. 33.

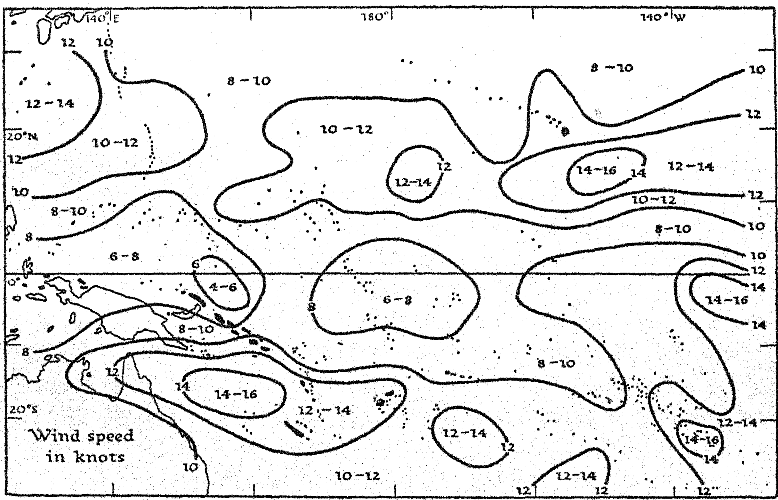

Fig. 36. Average surface wind speed in knots: September to November

For explanation and source see Fig. 33.

Strong Winds and Gales

It has been shown above that most of the winds within the tropics are less than 14 knots and that winds exceeding 28 knots are exceedingly rare. Really strong gales, reaching and exceeding 41 knots

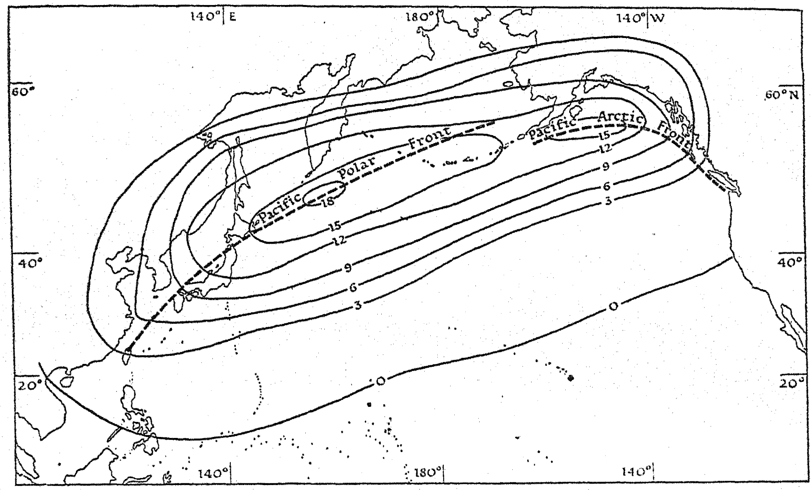

Fig. 37. Average frequency of depressions in winter

The months November to April are selected as the winter half-year. This figure is based on observations made during the period 1923–32. It is generalized from R. W. Richardson, 'Winter Air-Mass Convergence over the North Pacific', *The Monthly Weather Review*, pp. 199–203 (Washington, 1936).

(Beaufort force 9), are practically unknown in the central area, but they occur in certain fairly well-defined areas subject to tropical storms (typhoons or hurricanes). The distribution of these storms is shown in Fig. 38. They are revolving storms with an anti-clockwise rotation of winds north of the equator and a clockwise rotation south of the equator. The areas of origin of these storms (as shown in Fig. 38) correspond to areas of intense over-heating in regions of calms or light winds, provided that these occur far enough from the equator for rotational movement to be set up in the ascending air currents produced. Two principal regions are affected: (1) among the islands south of 15°S; (2) in the Western Pacific, off the Philippines and Japan.

In the northern hemispheres these storms generally follow a well-defined pattern of track—first westwards, then northwards,

then eastwards—though (exceptionally) many other routes may be followed. In the southern hemisphere, however, a curved track is not often followed; most storms move from north to south (Fig. 38). Not every typhoon produces winds of gale force, but probably half of them do, while velocities of 70 or 80 knots may be expected and 134 knots has been recorded on Guam. The radius of the typhoon circulation seldom exceeds 300 or 400 miles and the area of destructive winds may extend over a circle of about 100 miles radius from the centre, but it is usually less. The centre, or 'eye of the storm', though a region of calm or light winds, has mountainous sea and swell of a very destructive character. Torrential rain characterizes the central area, often producing 20 in. or more during the day or two of its passage; the record is 46 in. in 24 hours at Baguio, a mountain station in the Philippines. The hurricanes

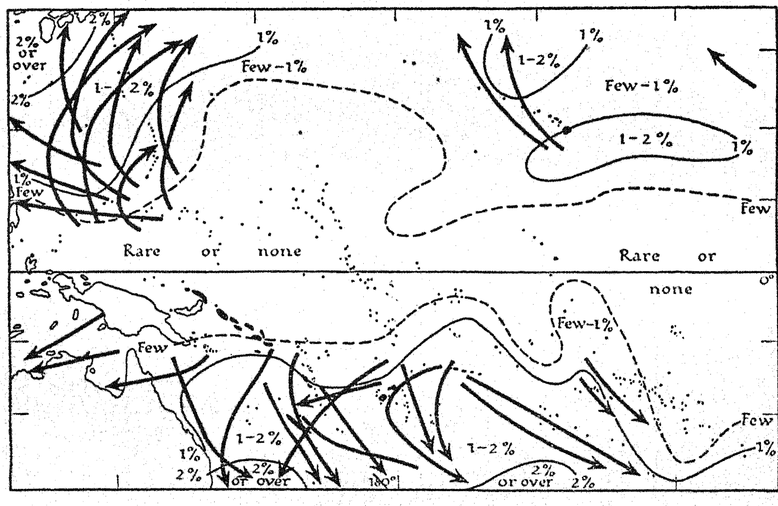

Fig. 38. Annual percentage frequency of strong gales and hurricanes

This figure records the frequency of winds of 41 knots or over (Beaufort force 9 or higher). The arrows show typical tracks of typhoons. Based on the U.S. Hydrographic Office, 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), chart 24.

of the south Pacific are not so violent as the typhoons of the China seas, but do great and lasting damage to low islands and atolls. These are sometimes completely washed over by the mountainous seas, with the destruction of every building and all crops.

In the south Pacific, hurricanes originate about lat. 10° s in the western half of the ocean and sweep south to about 30° s, but increase in frequency towards the west, affecting especially Samoa, Tonga, Fiji, the New Hebrides, New Caledonia and the coast of Queensland. Gales in these parts are mostly due to this source and about three per year may be expected (Table III, p. 96), mainly in the months of January to March.

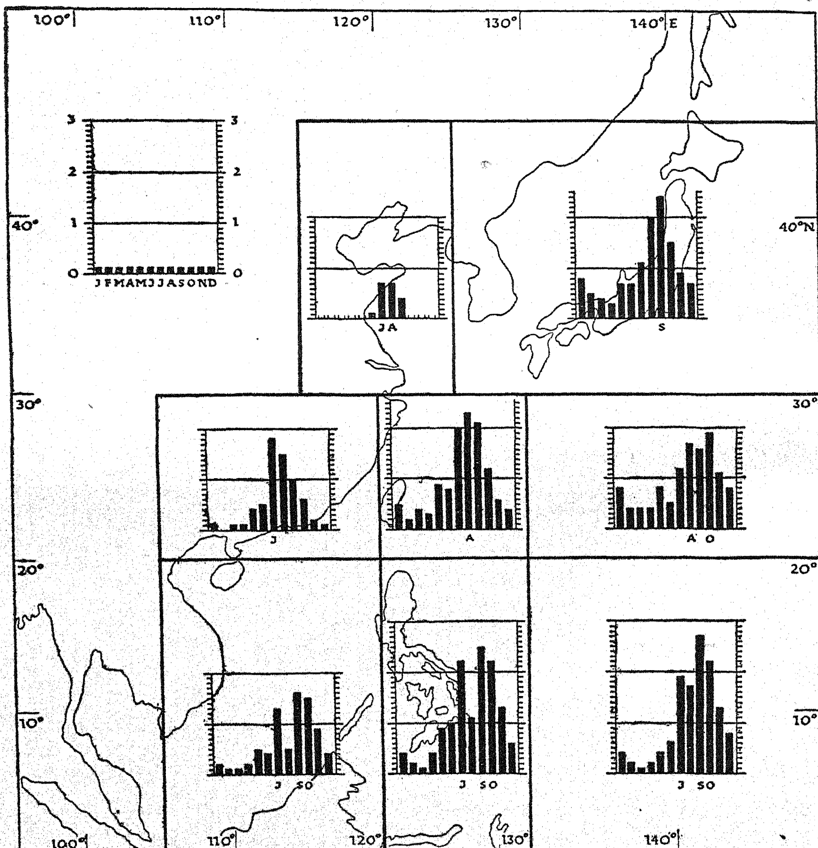

Fig. 39. Typhoon frequency in the China seas

The figure is calculated from observations over the periods 1893–1918 and 1929–31. The scale of frequency is indicated in the top left-hand corner of the map. The numbers show the averages per month. Months with maxima of typhoons are indicated by initial letters. Based on the Air Ministry Meteorological Office *Weather in the China Seas and in the Western Part of the North Pacific Ocean*, vol. 1, pt. 2, pl. 16, fig. 28 (London, 1938).

In the north Pacific hurricanes occasionally occur in the neighbourhood o the Hawaiian islands, originating about 15° N; but they are unusual features of the climate there.

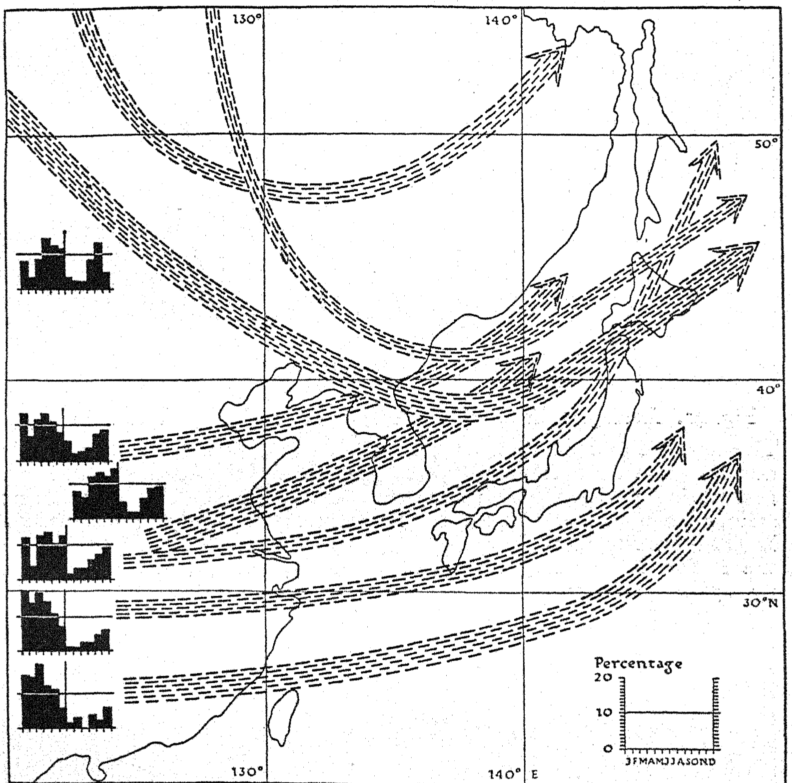

Fig. 40. Typical tracks of cyclonic depressions and their monthly frequency over the China seas

The thickness of the band indicates approximately the relative frequency with which depressions travel along these tracks. The diagram at the beginning of each track indicates the percentage frequency of depressions on that track in each of the twelve months; a vertical line has been drawn between the columns for June and July. Based on the Air Ministry Meteorological Office *Weather in the China Seas and in the Western Part of the North Pacific Ocean*, vol. I, pt. I, p. 53 (London, 1938).

In the China seas typhoons are an important element in the climate. They originate between latitudes 7° and 16° N according to the season, as follows:

	J	F	M	A	M	J	J	A	S	O	N	D
Lat. of origin (° N)	8	7	7	9	13	15	15	16	15	12	10	9

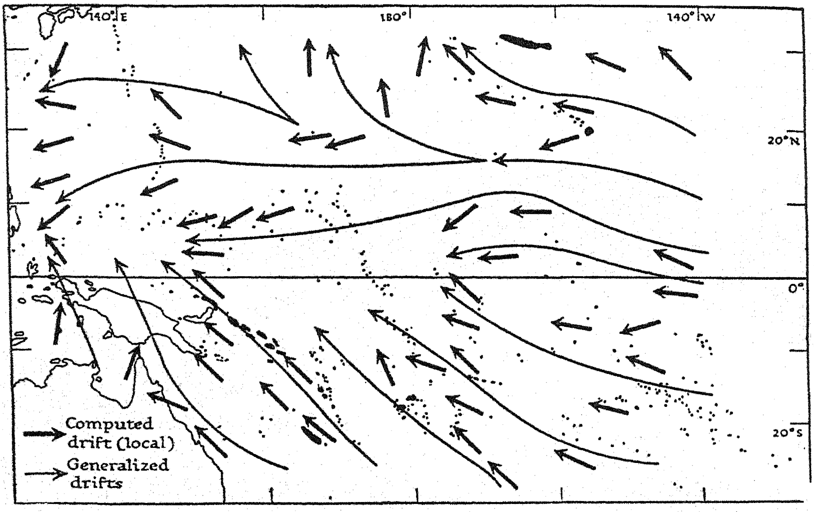

Fig. 41. Average drift of middle-level clouds: December to February

The results shown in Figs. 41–4 have been computed for a considerable number of well-distributed ocean squares by the method used for generalizing the surface drift from ships' observations. The observations mainly concerned the direction of movement of alto-cumulus clouds. Figs. 41–4 are based on the U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), pp. 25-6.

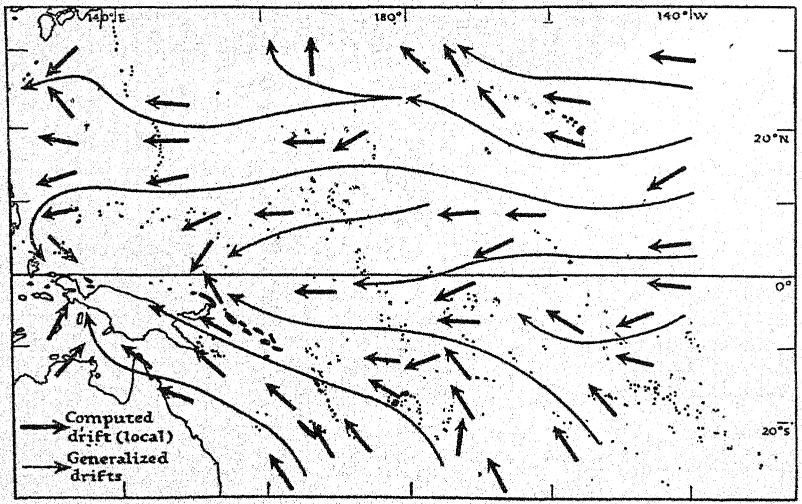

Fig. 42. Average drift of middle-level clouds: March to May

For explanation and source see Fig. 41.

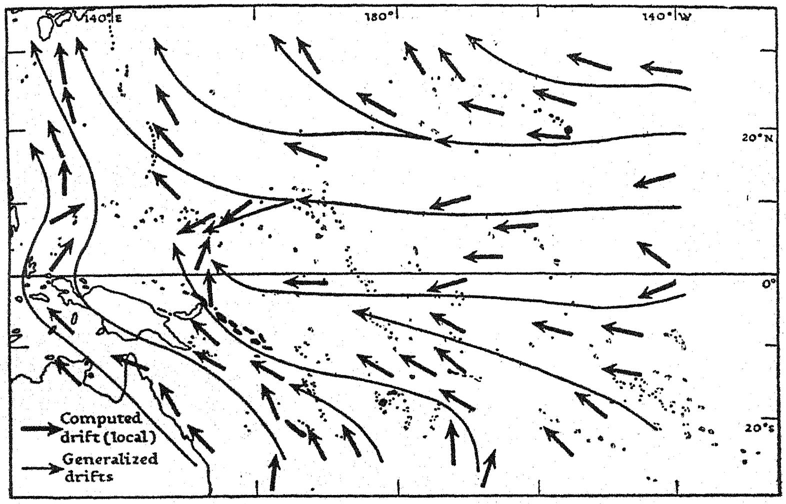

Fig. 43. Average drift of middle-level clouds: June to August
For explanation and source see Fig. 41.

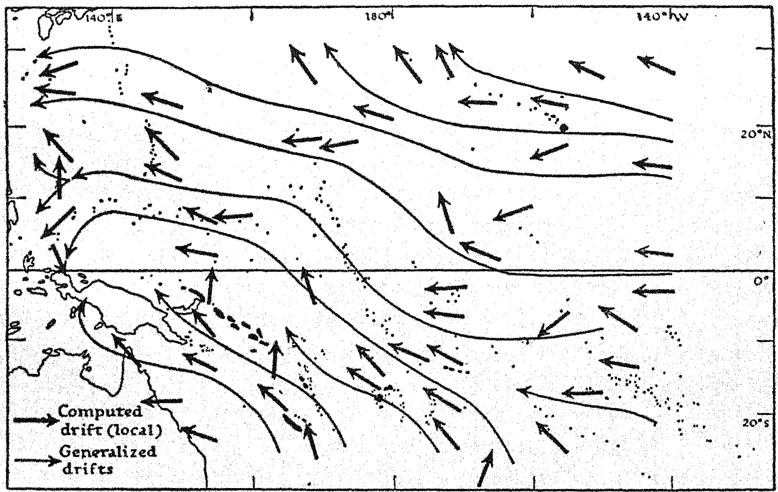

Fig. 44. Average drift of middle-level clouds: September to November
For explanation and source see Fig. 41.

The most prolific region of production lies east of the Philippines between Yap and Guam. Thereafter their tracks are, in general, as shown in Fig. 38. In January, February and March the majority of typhoons recurve before reaching the Philippine islands and pass away to the southward of Japan. In April and May the area affected spreads westward to include the Philippines, the Gulf of Tonkin and the Formosa strait. In June it spreads still further west and north and by July no part of the China coast from lat. 15° N to the gulf of Pohai is safe. In July and August the typhoons reach their furthest north, but by the end of August the tracks begin to move south again and the Philippines are in the danger area again in September. By October the Yellow sea and Japan are practically immune, but the coast of Indo-China remains in the danger area until January. The beginning of November marks the end of the typhoon season proper and the chance of meeting a typhoon between December and April is small. Fig. 39 shows the monthly frequency for eight rectangles of latitude and longitude.

Some of the gales occurring off China and Japan, especially during the winter months, are due to depressions of temperature origin and not to tropical revolving storms. Gales of this origin increase in frequency further north, until in lat. 40° N they may occur as frequently as 10 days per month in winter. Typical tracks followed by the temperate cyclonic depressions are shown in Fig. 40. Most of the depressions affecting the main and southern islands of Japan have their origin in China. As will be seen from the diagrams they are most frequent from December to June and are rare in July, August and September. The summer depressions rarely produce strong winds; most of the gales occur as a result of winter storms. Near the coast the gale winds are from a direction north of west, for the cyclonic circulation is reinforced in rear of the centre by the strong outblowing monsoon. Further out to sea the gales are often from south of west. In the belt of prevailing westerly winds gales become increasingly frequent with increasing latitudes (Table III, p. 96)—figures for Auckland and Tatoosh island.

Free Air Winds

Figs. 41–4 show that the prevailing wind, as shown by the average drift of middle level clouds, is everywhere towards the west. Within 10° of the equator easterly winds continue to prevail at all heights up to at least 16,000 ft., though even on the equator (at Nauru)

westerly winds occur occasionally (33% of winds at 6,000 ft.). In higher latitudes, however, an upper westerly wind (counter-trade) makes its appearance and becomes progressively more frequent, especially in winter, and is found at progressively lower levels as the region of the surface westerlies is approached. At Pearl harbour (20° N) the easterly winds prevail up to great heights in summer, but in winter a counter-trade occurs from a westerly direction above 10,000 ft. This is also recorded from Midway (8° N). At Tutuila in Samoa (14° S) there appears to be a definite counter-trade current at 16,000 ft.

The westward drift at middle heights is almost universal; but, during the summer monsoon of the northern hemisphere, there is a strong northward flow of air at these levels in the Western Pacific from the southern hemisphere towards the Asiatic low-pressure centre. No such diversion occurs during the winter monsoon, when the air at middle levels appears to flow westwards, over-riding the shallow current of the southward flowing winter monsoon. Winds increase in force up to 3,000 ft. and then decline steadily (Table IV, p. 97). Three-quarters of the winds are less than 15 knots (Beaufort force 4); gale winds of 28 knots (Beaufort force 7) or over are rare, occurring chiefly in winter at heights of 1,500 ft. to 3,500 ft.

TEMPERATURE

Figs. 45 and 46 show the January and July mean temperatures of the sea surface and of the air above the open sea. The air temperatures are based on the night-time observations (2100 hr. to 0300 hr.); the day temperatures would be only very slightly higher. The temperature of the air is slightly lower than that of the sea because the trade winds constantly bring cooler air from lower latitudes. The eastern side of the ocean is colder than the western, because of the volume of cold water imported by the currents and winds setting equatorwards along the coasts of North and South America, and because the trade winds sweep the warmer surface waters continually across the ocean from east to west.

Within the tropics the variation of temperature throughout the year is so slight as to be negligible. The average temperature in the coldest month is seldom less than 78° F. or in the hottest month more than 82° F.

At the tropics the range has increased to about 8° F. (70° to 78° F.),

and by 40° N or 40° S it may be 10° F., but is usually less. Island stations have a slightly higher range than the open sea, e.g., Midway (28° N) has a minimum in February (65° F.) and a maximum in August (78° F.). It is only where monsoon influences are felt that the temperatures fall below 50° F., e.g., at Kagoshima (February 45° F., August 80° F.). Winters here are unduly cold owing to the strong flow of polar continental air from the Asiatic mainland. The range of sea temperature is also large in these parts because the

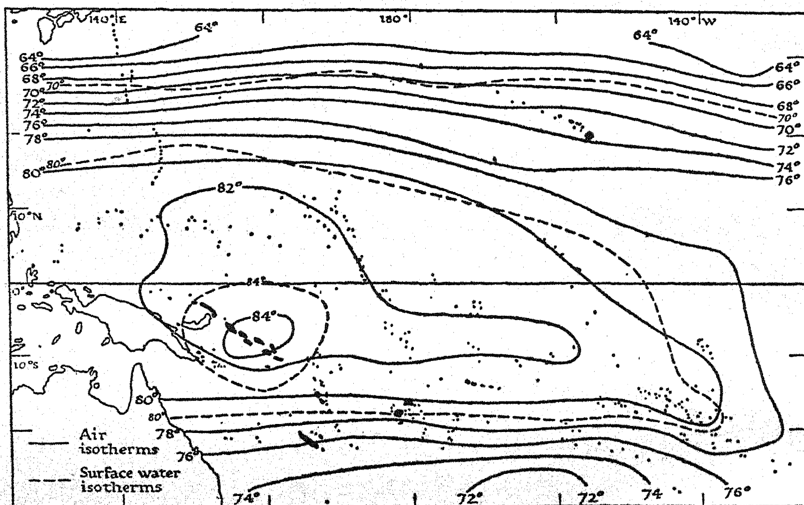

Fig. 45. Air and surface-water temperatures: January

The figures on this and Fig. 46 show degrees Fahrenheit. Figs. 45–6 are based on the U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), p. 10.

area influenced by the cold current extends much further south in winter. The range of sea surface temperature off the southern islands of Japan is from 60° F. to 80° F., while in the Tsugaru straits it ranges from 40° F. (Oya Shio water) to 68° F. (Kuro Shio water). Along the Kurile islands the sea temperature is near 32° F., and pack ice is experienced near the coast in the area affected by the cold Kurile current. The range of air temperature, like that of sea temperature is considerable in Japan. At Tokyo it ranges from 37° to 78° F. and at Nemuro, the most easterly point on Yezo, from 22° to 63° F. It will be noticed that, though winter temperatures are very low for their latitude, summer temperatures in and off

Japan are high because the wind is from the south-east, off the warm waters of the Kuro Shio.

The diurnal range of temperature is very small over the open ocean between the tropics and is small at island stations (usually about 8° F.). It is sufficient, however, to produce land and sea breezes which are described above. It increases with latitude; Hilo has a mean daily range in April of 13.5° F. (minimum) and in February of 15.5° F. (maximum). In the monsoon region of Japan it is greater still (Tokyo, 17.6° F. in January, 12.9° F. in July). This is the only place below 40° latitude where extremes of heat and cold are experienced (Tokyo has recorded 98° F. and 15° F.) and

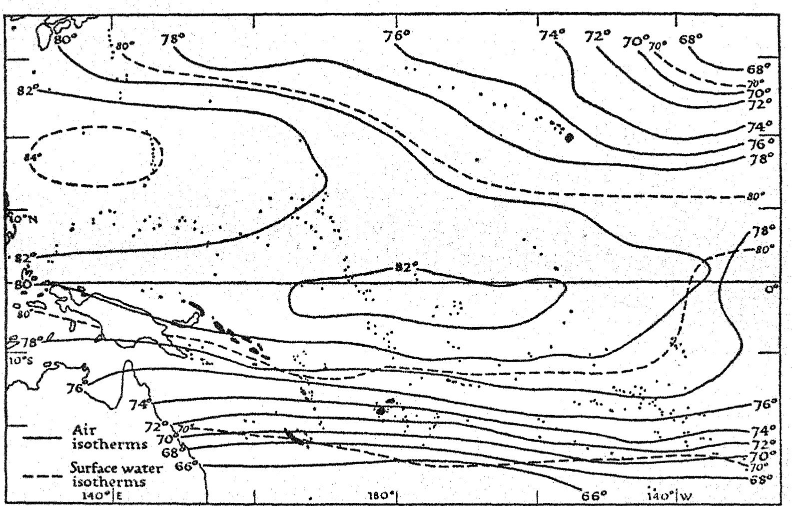

Fig. 46. Air and surface-water temperatures: July
For explanation and source see Fig. 45.

where freezing point is reached or surpassed. On the islands within the tropics the thermometer never reaches 100° F. or falls below 50° F. (Table V, p. 98).

The occurrence of heavy rains drives down the temperature; in the monotonously hot climates of the equatorial zone the thermometer may descend 12° F. to 15° F. in half an hour from this cause.

Many of the islands rise to considerable heights and some of them have fair-sized areas where the temperature is profoundly modified by this fact. In calculating the temperatures to be expected at high levels the usual formula (3° F. decrease per 1,000 ft.) works quite

well, as is shown by the figures for Nandarivatu, in Fiji, and for Volcano Observatory and Humuula, both in the island of Hawaii.

Monthly Temperatures

Station	Height in ft.	J	F	M	A	M	J	J	A	S	O	N	D	Year
Humuula	6,680	50·0	50·4	48·6	49·0	51·5	53·0	54·7	55·6	54·5	54·4	52·0	51·3	52
Volcano Obs.	3,937	57·8	58·6	59·0	59·4	61·0	62·0	62·8	63·4	63·2	62·8	60·6	59·2	60·8
Nandarivatu	3,002	69·4	69·0	68·4	67·2	66·4	66·0	65·6	65·4	65·7	66·6	67·8	68·6	67·2

HUMIDITY

At air temperatures between 70° and 80° F. a relative humidity of 65% implies a depression of the wet bulb temperature of about 8° F., 70% of about 7° F., 80% of 5° F., 90% of 2° F. The average depression of the wet bulb in the area is between 7° F. and 3° F., but in the doldrums it may be only 1° or 2° F. The average relative humidity for each month at ten stations is given in Table VI (p. 99). From this Table it is apparent that almost everywhere throughout the Pacific the air, though heavily charged with moisture, has nearly always a capacity for absorbing more. Ascent and consequent cooling are necessary to bring about condensation and to produce cloud or rain.

Summer is everywhere the season of highest humidity, being usually about 5% higher than winter. Greater contrasts, of the order of 10%, occur in regions influenced by the monsoon, e.g., Guam and Manila. The nocturnal fall of temperature causes the relative humidity to increase. To illustrate this the figures for Honolulu, Guam, and Afiamalu (an unusually humid station 2,000 ft. above sea level in the Samoa group) are given for morning, noon and night in Table VI. The humidity is 8% or 12% less in the middle of the day than at night. The figures for Guam (0600 hr.) and Honolulu (2000 hr.), however, show that even at night the air near sea level is far from saturated at most islands.

In consequence of these low humidities the central Pacific is a region of low cloudiness, averaging about 5/10, cumulus being the commonest type (Fig. 47). The islands in general show a higher cloudiness than the open sea, especially by day. This is to be expected, as the lower islands set up convection currents during the day, resulting in an afternoon maximum of cumulus or cumulo-nimbus cloud, while the higher islands force ascent of the air. Many

of the higher islands in the trade winds have an almost permanent cloud cap caused in this way. The cloud cap dwindles and may disappear if the wind drops (vol. II, pp. 308). The lowest cloud amounts (4/10) occur in the areas under the influence of the tropical

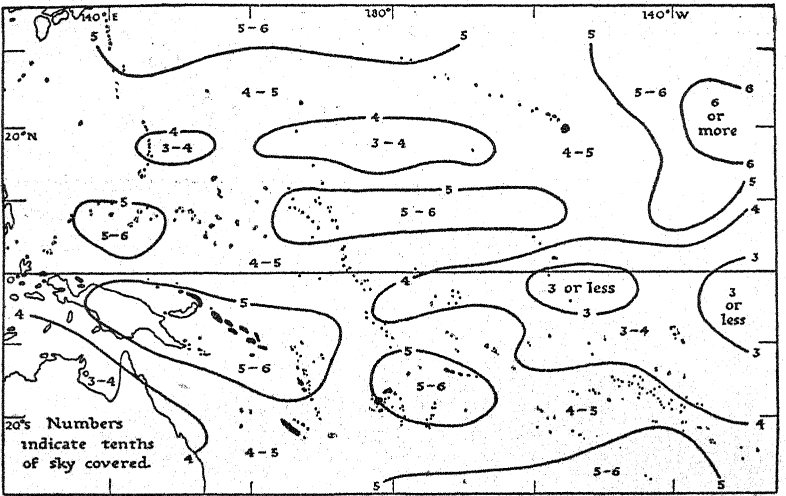

Fig. 47. Average annual cloud amount

This figure has been computed from ships' estimates. In general the amounts of cloud reported for island stations are higher than those observed over the open sea. Based on the U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), p. 52.

anti-cyclones. Cloud increases towards the doldrums where it exceeds 6/10 and (in summer) towards the west where the monsoons occur and the cloud amount also exceeds 6/10. The highest cloud amount occurs off the Peruvian coasts (7/10) and is due to the cold waters of the Peruvian current. The Pacific and its islands thus enjoy, on the whole, a sunny climate, experiencing 50% to 60% of the possible number of hours. The average duration of sunshine is given below (in hours).

Station	Latitude	J	F	M	A	M	J	J	A	S	O	N	D	Year
Honolulu	21° 18′ N	201	209	219	226	257	258	270	274	249	244	202	196	2,805
Saipan	15° 14′ N	186	167	239	261	263	258	175	222	168	184	207	199	2,529
Manila	14° 35′ N	173	205	224	257	215	162	132	130	134	157	156	148	2,103
Palau	7° 20′ N	172	187	227	211	182	185	146	176	188	170	192	169	2.205
Apia	13° 48′ S	142	153	172	188	197	187	204	223	218	204	175	158	2,221
Suva	18° 08′ S	196	165	170	156	125	130	152	132	144	163	168	208	1,909

VISIBILITY AND FOG

In the open ocean between the tropics visibility is generally good and often very good. Days of 'exceptional visibility' exceed one in ten in many parts. Fog is rare and hardly anywhere in these areas is it recorded on more than 2% of occasions. Haze is a little more frequent, but even this is reported on less than 3% of occasions in the inland region.

In two regions within the area considerable fog develops: (i) over the cold water that fringes the west coasts of the Americas in latitudes

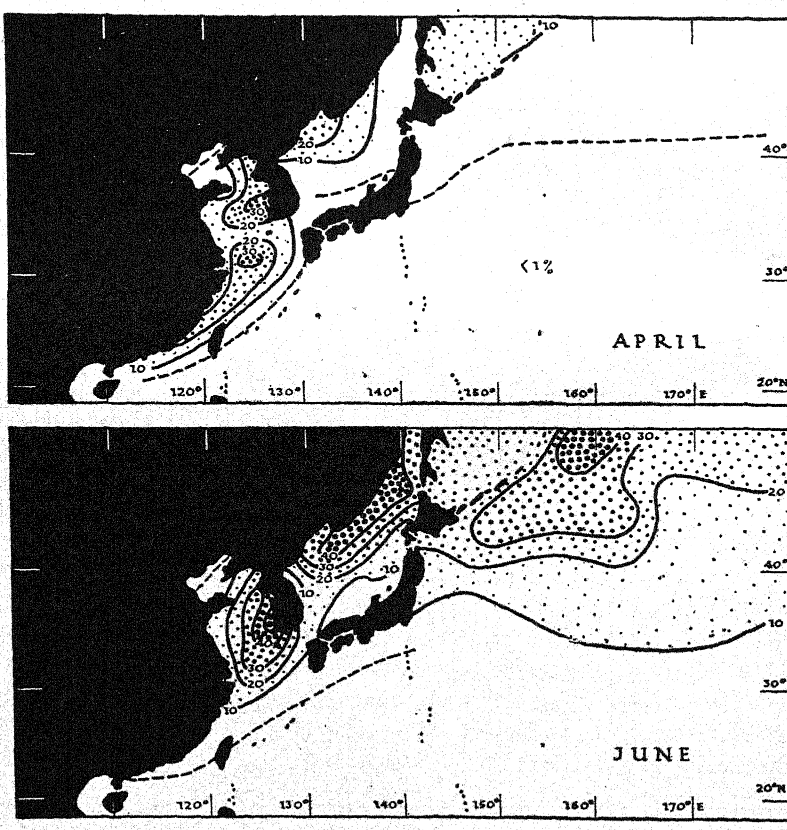

Fig. 48. Percentage frequency of fog over the sea in the north-west Pacific

The pecked line represents a frequency of 1%. Areas where the frequency exceeds 10% are stippled according to percentage frequency. Based on the Air Ministry Meteorological Office, *Weather in the China Seas and in the Western Part of the North Pacific Ocean*, vol. 1, pt. 1, pp. 148–9 (London, 1938).

30°–50° N and 15°–40° S; (ii) off Japan, where the cold waters of the Oya Shio or Kamchatka current chill the southerly winds in summer. This is one of the foggiest regions of the world, rivalling the Newfoundland banks. The foggiest region is off the Kurile islands, where fog is recorded on 40% of occasions in June. The area affected extends further south in the months of calmer weather (April and May) before the monsoon has gathered force. Fig. 48 shows the percentage frequency in April, when the fog is furthest south, and in June, when it is most severe further north.

Along the coasts of North and South America, washed by the cold currents, the frequency of fog is high (San Francisco has thick fog—visibility less than 1,000 ft.—on 19 days in the year, Eureka on 51 days), but the fog does not extend very far out to sea. Juan Fernández, however, nearly 400 miles from the coast, has fog on 25 days a year. The high humidity in these regions causes cloud to form readily at fairly low levels where the air is forced to ascend, as, for example, in the Galápagos, where it is known as the *garúa*.

Figures for some stations in these foggy regions are given in Table VII (p. 100).

Fog may be practically neglected in the central Pacific.

RAINFALL

The principal types of rainfall between lats. 30° N and 30° S can be classified as follows:

1. Convectional rain in the doldrum belt of convergence of trade winds. This lies generally north of the geographical equator, especially in the Eastern Pacific. Its annual migration has been described above, and the rainy season is, in general, the season when it covers the particular station. The rainiest parts of the Pacific, e.g., the Caroline and Marshall islands, derive most of their precipitation from this cause.

2. Orographic rain from the trade winds. This occurs all the year round but is apt to be heavier in winter than in summer because the trade winds are then stronger. It is characteristic of the higher islands on their windward side. Striking contrasts of rainfall occur for this reason on the windward and leeward sides of high islands such as those of New Caledonia, Fiji, Samoa and the Hawaiian islands. Waiawa (22 in.) and mount Waialeale (476 in.), both on the island of Kauai, may be taken as the driest and wettest stations in the whole of the Pacific.

3. Typhoon or hurricane rain, occurring during the hurricane season (pp. 68–71). It can be excessive while it lasts, but is infrequent at any one station. In higher latitudes rain is due to depressions of temperate origin. This affects the coasts of China and Japan in fairly low latitudes during winter, but elsewhere is not usual below 30° N or S. In the Lower Cook islands (lat. 20° S) some of the winter rain comes on westerly winds which are probably related to depressions, though this is generally the drier season. At Norfolk island in 29° S, winter rain predominates, as it does in New Zealand. Midway has some depression rain in winter, while the *kona* (meaning leeward or south-west) rains of the Hawaiian islands occurring in the winter half-year, though of short duration, are very heavy. On the lee side of the islands (as regards trade winds) the rainfall is normally very light, but a single *kona* rain storm, associated with a

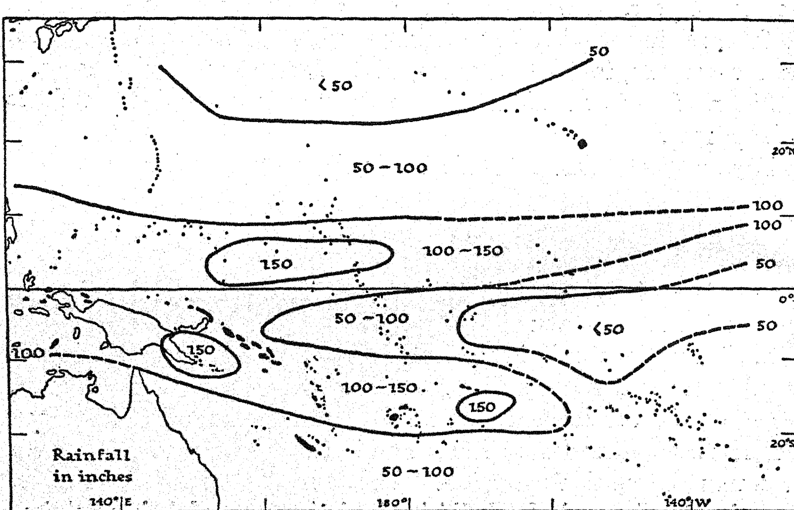

Fig. 49. Generalized annual rainfall

The isohyets are based on the average values for annual precipitation available for stations where consistent measurements have been made over a number of years. Based on the U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), p. 59.

depression to the north, may exceed the normal annual total. The smallness of the annual average, however, shows that *kona* rain is exceptional.

Because of the variety of altitude of the islands and the conse-

quent contrasts in the amount of orographic rain it is difficult to construct isohyetal maps, but Fig. 49 gives a general picture of the annual distribution of rain.

The heaviest rainfall, in many places exceeding 150 in., occurs along the equator on the western side of the ocean, including the Carolines and New Guinea. This belt of heavy rain branches to the east into a northerly belt between 5° and 10° N (including the Marshall islands and Fanning) and a southerly branch between 10° and 20° S (including the Solomon islands, Ellice islands and Samoa). Between these two arms there occurs, on and just south of the equator, a remarkable wedge of low rainfall, with less than 100 in. or, further east, less than 50 in. of rain. It includes Howland, Baker, Malden, Christmas, Jarvis, the Phoenix islands and extends eastwards to the Galápagos and the dry border of South America. Rainfall is, however, very variable in this wedge, and long wet spells may be experienced, during which the rain resembles that of the wet zones to north and south. Polewards from the wet belts described above, the rainfall diminishes towards the high pressure regions of the horse latitudes, but the decrease of rain is much less marked in the southern hemisphere than in the northern. Midway and Honolulu (lee side of Oahu) have less than 50 in.; no stations in the south show such low values.

Seasonal Distribution of Rain (*Table VIII, p.* 101)

Nowhere in the central Pacific is there a true dry season if monthly averages are considered, but this does not mean that droughts of considerable duration are not experienced. On many of the islands the rain is unreliable and may fail in the drier season, so that long droughty spells occur. In the equatorial wet belt rain is heavy at all seasons. But as we go north or south into the trade wind zones, a drier season begins to appear; this is generally 'winter' or 'spring' in either hemisphere, the wettest season being usually late 'summer' or 'autumn'. Towards the poleward margin of the trade wind zone the rain is more evenly distributed throughout the year and even tends eventually to have a winter maximum (e.g., in the Hawaiian islands). Still further from the equator the winter maximum is emphasized by the oncoming of winter depression rain belonging to the edge of the depression belt.

West of 150° E and north of the equator the effect of the proximity of Asia is felt, and the regime is clearly abnormal, resembling that of south China. Subject to numerous exceptions we can there-

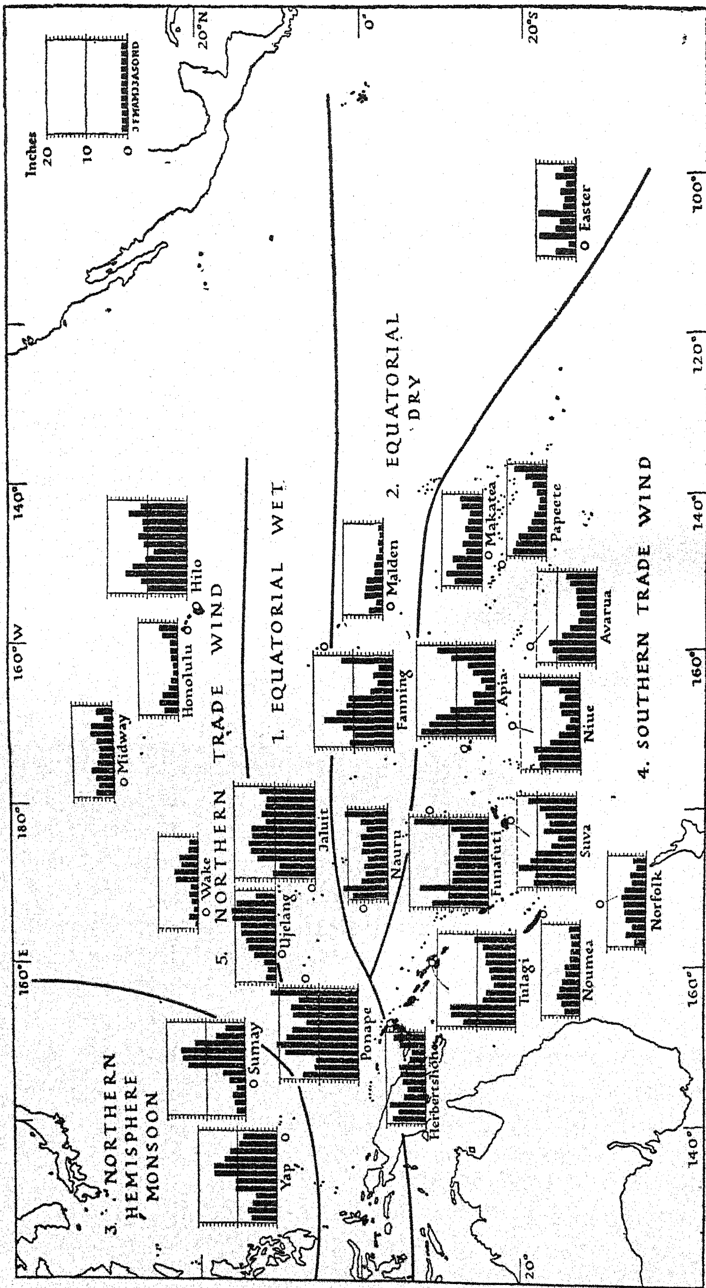

Fig. 50. Rainfall regimes and zones of the Pacific

The regions show the broad limits of rainfall regimes. Based on various sources.

fore recognize five rainfall regimes as follows. Their distribution and approximate limits are set out in Fig. 50.

1. Equatorial wet zone. Rainfall is heavy in all months and there is no dry season (e.g., in Jaluit).

2. Equatorial dry zone. Rainfall is light and very unreliable. The dry season is from September to December, and the wet season from March to May (e.g., in Malden island).

3. Monsoon regime of northern hemisphere. The winter is relatively dry with a summer maximum. There is usually a slight falling off in July or August (e.g., at Naha).

4. Southern hemisphere trade wind zone. Here is a late summer or autumn maximum, and a winter or spring minimum (e.g., at Papeete).

5. Northern hemisphere trade wind zone. The seasonal variation is slight, but there is a tendency to a winter maximum (e.g., in the Hawaiian islands).

Intensity and Nature of Rainfall

The figures given in Table IX (p. 102) show that the amount of rain occurring on each day that rain falls is relatively high, exceeding 0·4 in. at most stations. The rate of fall is lowest at lee stations

Variability of Rainfall

	Honolulu XII–II	Jaluit III–VII	Fanning II–V	Ocean I XII–II	Malden III–V	Avarua I–III	Apia XII–II	Suva II–IV
No. of years' observations	30	18	21	27	20	30	30	30
No. of years with 2 in. per month	30	0	17	24	20	23	19	30
% of years with 2 in. per month	100	0	81	89	100	77	63	33
No. of years with 1 in. per month	30	0	14	21	18	12	9	4
% of years with 1 in. per month	100	0	67	73	90	40	30	13
No. of years with 2 in. in 'wet season'	19	0	4	11	12	2	0	0
% of years with 2 in. in 'wet season'	63	0	19	41	60	7	0	0
% variability of rain	30	9	38	48	72	18	16	16

Figures in roman type beside the names of stations indicate the months of the wet season.

like Honolulu (0·2 in.) where the total rainfall is low, and highest at stations in the equatorial wet zone (e.g., Jaluit). It increases with altitude (e.g., compare Honolulu and Tantalus; Wailuku and Kaenae valley; Apia and Afiamalu). Added intensity is not, however, solely responsible for the increase of rain with altitude, rain is more frequent as well as heavier at high-level stations.

The most torrential rain is associated with tropical storms which will often produce 12 in. in 24 hours; 24 in. is not uncommon and Baguio, in the Philippines, once had 46 in. Orographic rains are often very heavy and continuous. The *kona* rains of the Hawaiian islands (p. 82) also give very heavy individual falls.

The figures quoted above show that periods of drought (months with less than 1 in. of rain) may occur quite frequently on all but the wettest islands in the equatorial wet zone (such as Jaluit), and in its southern extension (as at Apia and Suva). They also show that even in the wet season rains may fail to appear. December is the wettest month at Honolulu, with an average of over 4 in., but in fifteen out of fifty years between 1886 and 1935 the rainfall has been less than 2 in. At the other extreme 16 in. was recorded in 1927. Rainfall throughout the whole of Oceania is extremely variable. The greatest variations are found in the equatorial dry zone and on its borders. Ocean island had 178 in. in 1919, but only 14 in. in 1917. Malden had 94 in. in 1914, but only 4 in. in 1908. In the 21 years 1891–1918, 6 years at Malden had less than 10 in., and 5 years had more than 40 in. Figures of mean annual rainfall in such a climate have no meaning (vol. II, pp. 458–9). In this region, which lies between the trade winds of the two hemispheres, rain is usually scanty with east or south-east winds, but when the wind drops or shifts to the west rain usually occurs, often very heavily. Fanning island lies in the trade wind zone for part of the year and is relatively dry from September to November but comes into the calms from December to May (Table I, p. 91), when it has its wet season. In some years, however, such as 1907 and 1923, the trade winds affected the island for most of the year and rains were scanty.

The transition from the wet zones to the dry zone is very abrupt, and the change-over takes place in a very small distance from north to south. But although the boundary is normally about 2° or 3° N of the equator it shifts with the seasons, though still remaining abrupt. Thus at Christmas island and Malden (Table VIII, p. 101) the rains suddenly fall off in June as the dry conditions supervene

and begin abruptly again in January at Christmas island and in March at Malden. The movement of the boundary, however, is not reliable and regular, hence there arises great variability near the boundary—e.g., in the southern Marshall islands. Table X (p. 103) shows the month-to-month occurrence of rain at Ocean island and emphasizes the remarkable contrasts. Every month has in one of the 27 years exceeded 12 in., yet every month, except July and August, has at some time had less than one-third of an inch, and these two months have fallen below 1 in. at one time or another. The boundary between the dry zone and the rainy region of the south-east trades is also debatable; the Marquesas lie near the transition line.

Thunderstorms

In the central Pacific these are associated with the doldrum belt and are most frequent in the season of calms in late summer, which is also the rainy season. The rain of this season is mainly of the instability type and the instability of the atmosphere is often sufficient to produce thunder, mostly at night or in the early hours of the morning. North of 15° N and east of 140° W thunderstorms are rare, but they become more frequent towards the south-west and are most numerous in New Guinea and the Solomon islands, where they may be expected on 10 per cent. to 15 per cent. of occasions. Frequencies for twelve stations are given in Table XI (p. 104).

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CLIMATIC TABLES

I. *Percentage frequency of wind directions*

(i) Honolulu, Oahu (21° N, 158° W), 1905–30

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	7·2	38·5	27·2	4·5	6·7	8·9	3·8	2·8	0·4
F	7·4	38·7	27·0	4·2	6·4	9·4	3·7	2·8	0·4
M	7·3	40·2	31·1	4·8	4·7	6·1	3·0	2·4	0·4
A	4·2	47·1	35·4	3·3	3·7	3·1	1·7	1·3	0·2
M	2·7	54·4	40·8	3·1	3·1	3·3	1·5	0·7	0·4
J	1·6	43·6	48·4	1·7	2·0	1·7	0·5	0·3	0·2
J	0·9	43·4	52·1	1·5	0·9	0·5	0·3	0·3	0·1
A	0·9	44·7	49·9	1·5	1·1	0·9	0·4	0·3	0·3
S	2·0	43·0	47·2	2·1	2·8	1·6	0·6	0·6	0·1
O	3·5	43·8	40·6	2·7	3·4	3·6	1·1	0·7	0·6
N	5·8	45·8	34·9	2·8	3·9	3·5	1·7	1·2	0·4
D	6·8	38·9	33·7	5·0	4·7	5·5	3·0	2·2	0·2

(ii) Midway (28° N, 177° W), 1917–24

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	8	17	11	9	10	20	9	16	0
F	5	14	7	11	7	24	11	21	0
M	6	23	16	17	5	14	6	13	0
A	11	43	20	10	4	3	4	5	0
M	6	34	10	15	8	6	8	10	3
J	5	30	10	23	9	8	5	6	1
J	1	45	27	14	6	3	3	1	0
A	3	46	34	13	3	0	1	0	0
S	3	35	18	28	3	5	4	3	1
O	8	46	15	7	3	6	7	7	1
N	8	32	13	10	4	10	8	14	1
D	5	18	8	9	7	18	14	21	0

(iii) Guam (13° N, 145° E), 10 years

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	4	79	15	1	1	0	0	0	0
F	5	72	17	3	1	0	0	1	1
M	5	65	27	2	1	0	0	0	0
A	2	52	36	5	2	0	0	1	2
M	3	44	33	8	3	2	1	1	5
J	4	30	39	9	3	4	2	1	8
J	3	19	21	20	15	9	4	3	6
A	5	19	11	14	17	19	6	4	5
S	6	19	12	8	13	19	9	6	8
O	6	30	16	13	12	8	5	3	7
N	4	53	28	8	2	1	1	1	2
D	1	72	20	4	2	1	0	0	0

(iv) Yap (10° N, 138° E), 1906–30

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	2	72	21	1	0	0	0	0	4
F	3	75	17	1	0	0	0	0	4
M	5	69	18	2	1	0	1	1	3
A	3	58	24	2	1	2	1	1	8
M	3	39	32	5	3	2	2	1	13
J	5	26	27	8	5	6	4	2	17
J	7	14	12	9	7	16	11	5	19
A	6	7	4	4	8	28	22	5	16
S	8	10	7	5	8	19	16	7	20
O	7	18	10	4	6	15	14	8	18
N	9	40	19	5	4	4	4	4	11
D	3	54	26	6	2	3	2	0	4

(v) Jaluit (6° N, 170° E), 1892–9

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	2	67	18	7	1	1	0	0	4
F	2	61	24	9	1	0	0	0	3
M	0	63	24	8	1	0	0	0	4
A	2	44	35	12	2	0	0	0	5
M	1	39	38	9	2	1	0	1	9
J	1	45	36	7	2	1	1	0	7
J	1	33	32	13	2	1	0	2	16
A	0	31	31	15	4	2	1	1	15
S	1	15	20	28	10	3	1	1	21
O	4	15	27	30	6	4	2	2	10
N	5	35	28	19	3	2	0	1	7
D	2	63	21	8	1	1	0	0	8

(vi) Fanning (4° N, 159° W), 1903–18

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	1	18	22	57	1	0	0	0	1
F	1	25	35	38	1	0	0	0	0
M	1	36	43	20	0	0	0	0	0
A	1	34	45	17	1	0	0	1	1
M	2	25	44	19	4	1	0	1	4
J	2	12	36	41	4	2	0	1	2
J	0	5	30	55	5	1	1	0	3
A	1	2	23	64	3	1	0	1	5
S	0	3	24	64	5	1	0	2	1
O	1	2	15	68	6	5	1	2	0
N	0	5	28	57	1	3	1	2	3
D	1	15	31	50	0	0	0	2	1

(vii) Malden (4° S, 155° W), 1910–19

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	8	20	52	11	1	1	2	3	2
F	4	31	53	7	0	0	1	3	1
M	7	37	40	7	0	1	1	4	3
A	6	23	4[illegible]	17	0	1	1	4	6
M	3	27	45	21	0	1	0	1	2
J	2	17	54	26	0	0	0	0	1
J	0	10	56	31	1	0	0	1	1
A	1	13	55	30	0	0	0	0	1
S	1	14	52	32	0	0	0	0	1
O	1	18	46	28	1	0	0	2	4
N	4	25	46	21	0	0	0	3	1
D	3	29	49	14	0	2	1	1	1

(viii) Makatea (16° S, 148° W), 1910–13

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	9	16	30	2	1	2	7	10	23
F	11	19	19	2	1	2	8	10	28
M	5	15	41	7	0	1	1	7	23
A	6	9	31	16	1	0	0	8	29
M	10	12	25	26	2	0	0	4	21
J	2	14	48	15	0	1	0	1	19
J	2	10	54	10	1	2	1	1	19
A	2	7	47	22	3	1	0	1	17
S	1	12	55	15	2	0	0	0	15
O	2	12	52	13	2	1	1	2	15
N	3	16	47	10	0	0	0	5	19
D	8	16	40	12	0	0	1	6	17

(ix) Rarotonga (21° S, 159° W), 1929–33

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	13	20	22	17	12	4	3	3	6
F	4	18	33	14	12	3	5	6	4
M	5	14	27	17	14	5	4	8	5
A	3	12	29	15	19	6	4	4	9
M	3	12	24	17	23	6	5	2	8
J	10	10	19	15	20	10	4	5	5
J	8	11	20	11	18	8	10	4	10
A	7	10	21	23	17	8	7	4	4
S	3	12	30	18	16	5	8	2	4
O	7	14	28	30	11	3	1	2	3
N	7	17	29	22	18	3	1	3	1
D	10	22	24	16	14	4	3	6	3

(x) Apia, Samoa (14° S, 172° W), 1906–08

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	3	9	17	27	24	16	2	2	0
F	1	4	14	17	11	26	15	7	5
M	6	9	12	25	17	12	5	11	3
A	2	13	23	32	11	7	5	6	1
M	2	15	42	27	6	3	1	2	2
J	1	13	47	30	5	1	0	0	3
J	1	17	38	30	8	1	0	1	4
A	1	13	60	20	4	0	0	1	1
S	1	22	50	23	4	0	0	0	0
O	2	28	33	33	12	1	1	0	0
N	4	16	29	27	14	4	3	3	0
D	4	15	24	29	16	5	3	4	0

(xi) Suva, Fiji (18° S, 178° E), 33 years

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	10	21	27	24	4	6	2	2	4
F	13	19	29	19	5	3	2	3	7
M	13	21	25	17	4	7	3	2	8
A	9	19	28	25	4	5	1	2	7
M	8	15	25	30	5	6	1	3	7
J	8	14	25	30	4	3	2	5	8
J	9	17	23	31	6	3	2	3	6
A	6	14	28	29	5	7	1	4	6
S	6	17	27	35	4	4	2	2	3
O	5	16	35	30	5	3	1	2	3
N	5	16	35	29	6	4	1	1	3
D	8	14	31	28	5	5	3	3	3

(xii) Norfolk (29° S, 168° E), 12 years

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	7	9	32	23	10	6	6	5	2
F	5	13	34	26	9	3	3	4	3
M	3	6	28	37	15	4	2	2	3
A	8	11	25	24	12	6	7	4	3
M	7	8	20	17	12	12	14	7	3
J	8	10	8	12	9	14	23	12	4
J	6	3	11	14	13	21	22	7	3
A	5	8	15	15	14	15	16	8	4
S	12	9	15	14	11	14	13	10	2
O	11	11	13	16	11	15	13	7	3
N	11	4	14	26	12	10	10	9	4
D	14	12	23	22	10	6	6	5	2

(xiii) Easter island (27° s, 109° w), 1911–13

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	13	13	24	15	4	2	7	9	13
F	10	15	25	25	5	0	2	9	9
M	6	13	35	20	2	2	7	6	9
A	15	9	12	25	8	2	5	6	18
M	11	9	14	15	11	2	14	16	8
J	11	3	9	16	22	10	12	11	6
J	14	6	12	9	19	10	8	11	11
A	16	14	14	10	12	8	8	10	8
S	13	5	14	13	17	9	8	12	9
O	15	7	12	27	12	3	5	7	12
N	21	5	15	25	13	4	4	3	10
D	7	8	22	28	12	3	6	4	10

(xiv) Juan Fernández (34° s, 79° w), 19 years

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	calm
J	0	0	1	22	34	18	3	4	18
F	0	0	1	20	35	12	5	6	21
M	1	0	0	18	36	14	5	6	20
A	2	2	2	16	20	14	11	10	23
M	2	1	2	13	22	13	13	13	21
J	5	16	5	9	14	21	8	12	10
J	4	14	6	12	14	21	6	13	10
A	1	2	1	13	24	17	11	8	23
S	1	2	1	14	26	15	10	9	22
O	0	1	2	12	30	22	6	5	22
N	1	1	1	16	26	19	7	6	23
D	1	1	1	17	31	17	6	4	22

Based on: (1) G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, pp. 99–101 (Berlin, 1938); (2)—for Juan Fernández—U.S. Hydrographic Office *Sailing Directions for South America*, vol. III, p. 440 (4th edition, Washington, 1938).

II. *Percentage frequency of surface winds of different velocity*

Station or Square	Period	Velocity in knots				
		0–3	4–14	15–28	29–41	over 41
Pearl harbour, Oahu	May –Oct.	13·3	66·5	20·1	0·1	—
	Nov.–June	18·2	64·7	16·7	0·4	—
Sumay, Guam	July –Oct.	34·8	63·9	1·3	—	—
	Nov.–June	17·9	80·0	2·1	—	—
Palau	Sept.–Oct.	43·8	56·2	—	—	—
	Nov.–Dec. and Feb. –May	44·0	55·0	1·0	—	—
Apia, Samoa	Apl. –Nov.	31·8	68·2	—	—	—
	Dec. –Mar.	48·2	51·8	—	—	—
Square 20°–25° N, 155°–160° W	May –Oct.	6·6	67·2	25·8	0·4	—
	Nov.–Apl.	17·7	51·3	30·0	1·0	—
Square 15°–20° N, 150°–175° E	July –Oct.	3·8	54·7	39·6	1·9	—
	Nov.–Jan.	—	54·6	45·4	—	—
Square 10°–15° N, 130°–150° E	July –Oct.	3·1	69·6	27·3	—	—
	Nov.–June	—	68·7	31·3	—	—

Based on U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), pp. 34-51.

III. *Number of days with gales (28 knots or over)*

	J	F	M	A	M	J	J	A	S	O	N	D	Year	No. of years observations
Apia, Samoa	2	1	2	—	—	—	—	—	—	—	—	—	5	9
Suva	0·1	0·1	0·2	—	—	—	—	—	—	—	—	0·4	0·5	46
Rabaul, N. Britain	0·6	0·4	0·7	0·5	0·1	0·1	0·1	—	—	0·3	0·5	0·1	3	16
Yap	1	0·8	0·8	0·4	2·0	0·5	0·8	0·3	1	0·7	0·7	1·0	10	4
Ujelang	1·5	0·5	—	—	—	0·3	—	—	—	0·5	0·5	—	3·3	4
Malden	0·6	—	—	0·1	—	0·4	—	0·2	0·1	0·5	—	—	2	10
Fanning	—	—	—	—	0·1	—	—	—	—	—	—	0·1	0·2	14
Futuna, New Hebrides	0·6	0·5	—	0·1	0·3	0·1	—	0·9	0·1	0·1	—	—	3	9
Tulagi	0·5	0·3	0·3	—	0·2	0·8	0·8	0·6	0·5	0·1	—	0·1	4·2	18
Thursday I.	—	—	—	—	—	—	0·1	—	—	—	2	—	3	5
Tonga	0·3	0·3	1	—	—	—	—	—	—	0·5	—	0·5	3	4
Tatoosh I., Washington	19	15	14	10	5	3	2	2	6	12	17	19	124	38
Easter I.	—	—	1	—	—	1	1	0·7	0·7	0·3	—	0·7	5·4	2–3
Auckland (N.Z.)	2	2	2	2	3	3	3	3	3	3	3	3	32	61

Based on: (1) U.S. Hydrographic Office 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*); (2) Admiralty *West Coast of Central America and United States Pilot*, p. 406 (5th edition, London, 1935); (3) Admiralty *Pacific Islands Pilot*, vol. III, p. 243 (6th edition, London, 1931); (4) Admiralty *New Zealand Pilot*, p. 401 (10th edition, London, 1930).

IV. *Average wind velocity in knots at different heights (from pilot balloon observations)*

Station	Surface		1,600 ft.		3,300 ft.		6,600 ft.		9,800 ft.	
	Summer	Winter	S	W	S	W	S	W	S	W
Pearl harbour, Oahu	9·7	8·7	12·3	12·0	13·2	12·2	10·8	10·9	9·6	11·1
Sumay, Guam	4·8	5·9	13·7	18·1	13·6	18·8	12·7	14·3	11·4	12·6
Palau	3·5	3·4	11·6	15·0	12·0	13·7	8·2	9·2	—	8·5
Apia, Samoa	4·0	5·2	10·8	12·2	10·8	11·4	10·2	9·9	10·4	9·5

Based on U.S. Hydrographic Office, 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), p. 32.

V. *Mean, extremes, and range of temperature (in degrees F.)*

Station	Latitude	Mean temperature		Mean extreme		Recorded extreme		Daily range	
		Warmest month	Coldest month	Max.	Min.	Max.	Min.	Jan.	July
Ocean I.	1° 52′ S	81·1	80·8	92	71	96	68	13·1	12·2
Malden	4° 01′ S	82·6	81·5	93	68	99	65	13·6	13·5
Apia, Samoa	13° 48′ S	79·3	77·1	91	65	96	61	9·7	12·1
Guam	13° 24′ N	82·8	78·8	91	69	93	64	8·6	10·3
Honolulu	21° 19′ N	78·4	70·7	86	59	88	52	10·0	9·8
Norfolk	29° 04′ S	71·6	60·6	84	49	89	47	9·9	9·2
Taihoku, Formosa	25° 02′ N	82·4	58·3	97	41	99	32	12·3	16·0
Tokyo	35° 41′ N	77·7	37·4	93	21	98	15	17·6	12·9

Based largely on G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T (Berlin, 1938).

VI. *Relative humidity (percentage)*

Station	Latitude	J	F	M	A	M	J	J	A	S	O	N	D	Year
Ocean I.	0° 52′ S	77	77	76	78	75	75	74	73	74	74	75	75	75
Malden	4° 03′ S	70	71	72	74	73	71	69	68	66	66	65	67	69
Yap	9° 29′ S	82	82	81	82	84	85	86	86	85	86	85	84	84
Guam	13° 27′ N													
(0600 hr.)		84	84	84	83	84	85	88	90	89	88	87	85	86
(1400 hr.)		72	71	69	67	68	71	75	78	78	78	76	73	73
Apia, Samoa	13° 48′ S	85	85	85	85	84	83	82	80	81	82	83	83	83
Afiamalu, Samoa	13° 55′ S													
(0600 hr.)		95	95	95	93	93	93	94	94	92	91	93	93	93
(1300 hr.)		87	85	87	87	83	82	83	81	82	81	85	85	84
(2000 hr.)		95	95	96	95	94	93	94	94	93	93	94	96	94
(mean)		92	92	93	92	90	89	90	90	89	88	91	91	90
Manila	14° 35′ N	78	74	72	70	76	81	85	85	86	84	83	81	80
Honolulu	21° 18′ N													
(0800 hr.)		71	70	69	67	66	66	66	67	67	68	70	72	68
(1300 hr.)		64	62	62	62	60	60	60	60	60	62	64	65	62
(2000 hr.)		72	72	71	71	70	70	69	70	70	71	72	73	71
Rarotonga	21° 12′ S	85	84	82	81	75	79	79	74	77	77	79	82	80
Norfolk	29° 03′ S	80	82	82	83	82	82	81	80	81	80	78	79	80

Based on: (1) G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, p. 102 (Berlin, 1938); (2) C. Braak, 'Klimakunde von Hinterindien und Insulinde', *Handbuch der Klimatologie*, Band IV, Teil R, p. 112 (Berlin, 1931).

VII. *Number of days with fog*

Station or area	J	F	M	A	M	J	J	A	S	O	N	D	Year
Vladivostok	2	2	4	7	12	15	17	12	2	3	2	2	80
Ocean area, 35°–40° N, 140°–145° E	0	0	0·3	0·6	1·2	3·6	4	2	0·3	0	0	0	12
San Diego, California	2	3	1	1	1	1	1	1	2	4	3	2	22
Tatoosh I., Washington	1	1	1	1	3	4	8	12	8	5	1	1	46
Arica, Northern Chile	0	0	0·1	0·3	0·1	0	0	0	0·1	0	0	0	0·6
Juan Fernández	2	1·5	1·5	3	3	3	3	2	1·5	1	1	3	25·5
Easter	0	0	0	0·5	3	1	1	0·3	0·3	0·3	0	0	6
Ocean area, 40°–45° S, 120°–125° W	8	11	0	0	8	0	8	0	3	10	6	8	62

Based on various sources.

VIII. *Monthly means of rainfall (inches)*

Station	Height in feet	Period	J	F	M	A	M	J	J	A	S	O	N	D	Year
Summit camp, Kauai	1,870	1910–1924	19·8	9·1	17·9	14·5	13·2	11·1	13·0	12·0	13·3	13·7	15·7	15·8	169
Honolulu	56	1877–1935	3·4	4·0	3·2	2·1	1·4	0·8	1·0	1·2	1·5	1·8	3·4	3·9	27·7
Tantalus, Oahu	1,339	1905–1924	10·2	7·0	9·1	9·0	6·8	6·9	7·4	8·0	7·6	7·0	9·1	11·1	99·2
Kaenae valley, Maui	984	1905–1924	18·6	17·9	22·4	26·1	17·7	16·0	18·6	22·0	18·3	16·5	23·0	25·0	242·1
Hilo	39	1905–1924	13·2	10·5	15·7	13·2	9·2	8·5	9·7	12·4	12·4	11·5	15·7	13·4	145·4
Midway	20	1921–1930	4·3	3·8	3·4	4·4	3·1	2·3	4·1	3·6	5·2	2·5	2·6	2·8	42·1
Guam	62	1906–1922	2·4	3·1	3·2	2·2	4·0	5·7	14·1	15·5	16·3	12·4	7·3	4·7	90·9
Naha, Ryukyu Is.	34	1891–1920	5·3	5·3	6·0	6·3	9·8	10·4	7·1	10·0	7·1	6·7	5·7	4·1	83·8
Manila	46	1885–1925	1·0	0·5	0·7	1·3	4·4	9·9	10·2	16·1	14·4	7·3	5·6	2·4	79·8
Baguio	954	1903–1926	1·0	0·9	1·9	4·5	15·7	19·3	40·1	47·1	31·1	14·8	3·5	1·8	181·7
Koror, Palau	<33	1905–1913	8·6	7·7	7·7	7·0	11·5	12·2	18·0	15·2	11·2	9·6	13·3	15·0	137·0
Palau	105	1924–1929	15·7	8·3	6·8	8·0	17·2	13·1	24·4	15·3	12·9	15·3	10·0	13·7	160·7
Yap	115	1900–1930	7·0	6·8	4·9	5·2	9·6	10·7	16·5	16·3	13·3	11·7	10·2	8·9	121·1
Truk	<33	8 years	7·0	9·1	9·5	11·7	12·2	10·2	13·1	13·3	13·3	10·3	11·4	10·3	131·4
Ponape	<33	1901–1913	11·1	8·8	14·1	19·5	20·0	13·7	16·5	16·1	15·4	15·5	16·5	16·0	183·2
Ujelang	<30	1894–1912	2·1	2·2	2·6	6·2	6·3	7·4	8·5	8·7	10·8	10·1	10·9	4·9	80·7
Jaluit	10	1892–1913	9·6	8·8	14·3	16·4	16·0	15·0	15·2	11·7	13·4	11·9	12·0	13·2	157·5
Fanning	10	1903–1930	10·1	10·9	10·6	13·7	12·3	10·2	8·4	4·5	3·2	3·6	3·1	8·3	98·9
Ocean I.	92	1904–1930	11·8	9·2	7·5	6·1	4·4	4·5	6·3	4·6	4·3	4·3	5·9	9·0	79·7
Kokopo, New Guinea	213	1902–1913	8·0	7·5	8·8	5·5	4·3	5·8	5·9	6·2	4·0	3·3	6·3	7·8	73·4
Tulagi, Solomon Is.	7	1898–1922	13·0	16·5	15·2	10·1	7·5	6·3	7·7	6·8	8·2	8·5	9·6	10·2	119·6
Abaiang	13	1905–1907	13·6	6·0	8·0	11·1	6·5	6·9	6·8	2·9	2·1	10·2	6·7	7·3	88·1
Christmas	<33	1916–1919	6·9	5·4	5·0	4·6	5·5	1·9	2·6	1·1	1·0	0·6	0·3	2·2	37·1
Malden	26	1890–1925	3·4	2·1	4·5	4·6	4·2	2·1	1·9	1·5	0·8	0·9	0·7	0·8	27·5
Papeete, Tahiti	23	1880–1909	8·3	9·2	7·4	4·5	3·3	3·2	1·6	2·0	2·3	3·8	5·5	2·6	60·7
Makatea	128;154	6 years	6·7	8·8	6·1	7·1	3·6	4·8	3·2	4·3	3·6	3·3	5·0	5·5	62·0
Avarua, Rarotonga	23	1899–1935	9·8	10·5	11·5	7·3	5·4	4·4	4·6	4·4	4·5	5·1	6·1	9·2	82·8
Apia, Samoa	10	1890–1932	17·0	16·1	13·5	10·2	6·3	5·2	3·0	3·4	5·0	6·6	10·4	14·0	110·7
Tutuila	—	1900–1921	21·6	24·8	18·7	18·0	15·0	14·6	9·7	7·5	13·1	15·5	19·6	18·6	196·7
Alofi, Niue	69	1906–1935	10·5	11·5	12·7	7·5	4·7	3·0	3·3	4·6	3·9	4·6	5·9	9·0	81·2
Suva	23	1886–1934	11·3	12·0	14·8	12·8	10·0	6·5	5·2	8·1	7·6	8·5	9·9	12·0	118·7
Vila, New Hebrides	—	1905–1912	11·8	8·6	12·7	9·8	4·9	2·4	2·3	2·9	6·7	3·8	11·5	9·1	86·5
Noumea	<33	1860–1914	3·7	5·1	5·7	5·2	4·4	3·7	3·6	2·6	2·5	2·0	2·4	2·6	43·5
Lifu, Loyalty Is.	39	1908–1914	8·6	8·5	9·6	10·4	4·0	3·6	5·4	3·9	3·5	2·6	2·7	2·4	65·2
Norfolk	56	1887–1923	3·5	5·7	3·8	4·3	5·4	5·9	6·3	5·7	4·0	4·0	2·8	3·4	54·8
Kermadec Is.	7	1908	—	6·8	6·9	11·3	6·8	5·9	6·4	9·3	3·9	8·9	—	—	66·2
Easter	98	1911–1913	5·2	1·6	9·0	5·1	3·9	9·5	3·2	2·6	3·5	2·2	5·0	2·9	53·7

Based mainly on: (1) G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, pp. 37, 92–8 (Berlin, 1938); (2) C. Braak, 'Klimakunde von Hinterindien und Insulinde', *Handbuch der Klimatologie*, Band IV, Teil R, pp. 102–8 (Berlin, 1931).

IX. *Amount of rain per rain day (inches)*†

Station	Annual rainfall	Number of rain days	Rain per rain day	Height in feet
Makaweli, Kauai	24·4	93	0·26	138
Honolulu	27·7	159	0·18	56
Tantalus, Oahu	99·2	272	0·37	1,339
Wailuku, Maui	28·3	101	0·28	174
Kaenae valley, Maui	242·1	296	0·82	984
Hilo	145·4	279	0·52	39
Midway	42·1	162	0·26	20
Sumay, Guam	90·9	212	0·43	62
Garapan, Saipan	82·8	210	0·40	33
High station, Saipan	97·8	279	0·35	679
Palau	160·7	234	0·59	105
Yap	121·1	259	0·47	115
Ponape	183·2	266	0·69	<33
Lele harbour, Kusaie	176·8	239	0·57	<33
Ujelang	80·7	227	0·36	30
Jaluit	157·5	235	0·67	10
Fanning	98·9	160	0·61	10
Ocean I.	79·7	153	0·51	92
Christmas	37·1	151	0·24	<33
Malden	27·5	88	0·31	26
Papeete, Tahiti	60·7	125	0·48	23
Makatea	62·0	175	0·35	*c.* 130
Avarua, Rarotonga	82·8	183	0·47	23
Iva, Samoa	129·3	197	0·65	33
Apia, Samoa	110·7	188	0·59	10
Afiamalu, Samoa	189·8	284	0·67	1,969
Neiafu, Tonga	80·8	154	0·53	<33
Suva	118·7	248	0·48	23
Noumea	43·5	130	0·34	33
Norfolk	54·8	149	0·37	56
Easter	53·7	208	0·26	98

† A rain day is, in general, a day on which there was a rainfall of more than 1/100 in.

Calculated from G. Schott, 'Klimakunde der Südsee-Inseln,' *Handbuch der Klimatologie*, Band IV, Teil T, pp. 92–9, 103–4 (Berlin, 1938).

X. *Monthly and yearly rainfall at Ocean island, 1904-30 (in inches)*

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
1904	5·6	0·1	0·8	0·2	0·6	1·2	10·2	6·9	3·4	5·3	5·7	14·9	54·9
1905	22·2	20·6	5·7	20·7	10·4	12·5	8·7	4·7	12·4	13·6	9·6	9·0	150·1
1906	13·8	8·9	3·6	0·8	0·3	0·9	1·5	0·6	0·7	0·6	15·6	5·7	53·0
1907	8·6	2·8	7·7	8·8	1·0	2·4	2·8	0·9	1·1	7·6	9·4	5·0	58·1
1908	24·8	10·2	0·1	0·3	1·2	8·7	3·0	3·9	1·1	0·1	0·1	2·0	55·5
1909	2·7	0·4	1·1	0·2	0·6	1·2	5·7	2·4	2·3	0·8	1·0	0·4	18·8
1910	1·3	1·4	0·1	0·04	7·2	2·0	4·6	1·5	1·2	0·7	2·3	6·2	28·5
1911	3·9	6·4	26·2	26·8	5·4	8·5	7·6	4·7	11·2	14·4	7·6	20·8	143·5
1912	23·3	16·5	28·8	12·6	6·8	4·6	4·4	1·3	4·0	11·0	4·3	16·8	134·4
1913	13·6	17·6	1·6	1·3	1·8	0·2	3·4	4·3	5·6	6·4	9·3	12·3	77·4
1914	16·9	12·7	15·0	17·2	15·4	13·0	23·7	8·5	5·9	1·9	9·4	15·2	154·8
1915	14·6	9·4	10·3	13·0	21·7	3·9	1·8	0·6	0·5	0·0	0·2	2·8	78·8
1916	8·6	1·4	0·7	0·1	0·9	0·7	0·7	0·6	0·6	0·3	0·04	0·04	14·6
1917	0·2	0·4	0·1	0·9	0·3	2·5	1·6	0·7	3·3	0·2	0·4	3·8	14·3
1918	0·2	0·5	7·7	1·9	3·9	4·6	19·0	14·3	13·9	4·7	8·7	19·4	98·8
1919	17·0	23·8	21·2	17·7	7·5	8·0	14·3	14·0	13·2	17·6	6·9	13·9	175·1
1920	12·5	16·0	17·1	3·9	5·3	10·3	6·5	1·4	1·2	0·3	0·2	7·2	81·9
1921	16·9	1·7	0·7	0·5	1·0	0·7	3·9	1·3	2·4	1·6	3·3	14·3	48·3
1922	17·4	10·2	0·6	3·1	5·2	2·2	8·2	3·7	1·2	0·04	2·4	1·5	55·7
1923	4·9	5·4	14·4	9·2	0·3	8·6	5·6	17·1	2·0	5·4	11·7	15·8	100·4
1924	31·2	5·1	4·3	0·1	5·1	1·6	2·4	0·9	0·3	2·3	0·2	0·04	53·5
1925	0·5	0·8	1·3	0·04	1·3	5·4	3·9	6·8	2·5	12·6	4·8	8·8	48·7
1926	12·2	14·5	20·1	17·7	11·8	6·9	3·8	6·9	2·3	0·4	4·1	2·0	102·7
1927	0·2	0·2	0·4	0·1	2·2	2·7	6·2	1·7	1·9	0·3	5·8	18·3	40·0
1928	19·5	10·1	0·2	0·8	0·1	1·1	2·6	2·2	2·6	0·7	1·3	3·1	44·0
1929	10·9	21·4	2·1	1·0	4·6	3·5	7·7	9·9	1·1	1·7	13·0	15·4	92·3
1930	21·0	15·2	13·7	2·3	0·2	2·0	8·4	6·5	16·6	7·4	20·3	13·7	127·3
Average	12·0	8·7	7·6	6·0	4·5	4·4	6·4	4·7	4·3	4·4	5·8	9·2	77·9

Based on G. Schott, 'Klimakunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, p. 107 (Berlin, 1938).

XI. *Number of thunderstorms*

	J	F	M	A	M	J	J	A	S	O	N	D	Year	No. of years observation
Midway	1·0	0	0	0·5	0·4	0·2	0·2	1·0	0·2	1·4	0	0·2	5·1	5
Honolulu	1·2	0·6	0·7	0·2	0·4	0·1	0	0·1	0·1	0·2	0·3	0·9	4·8	20
Sumay, Gu m	0	0	0	1	0	1	2	2	3	3	3	0	15	5
Yap	1	0·3	1	1·3	1·3	2·0	2·3	3·0	5·7	2·3	3·5	1·7	25·4	3
Jaluit	0·2	0·6	2·0	1·7	2·0	2·2	3·2	2·3	2·3	1·5	2·3	1·2	21·5	5
Fanning	1·7	0·6	3	1·3	2·0	1·4	0·9	0·6	1·1	0·9	1·0	0·9	12·7	8
Ocean I.	1·4	0·5	0·7	0·2	0·2	0·6	0·7	0·2	0·6	0·4	0·6	0·6	6·7	10
Kieta, Solomon Is.	9·0	9·9	11·7	5·3	3·3	3·3	0·3	0·5	2·4	3·7	4·3	6·4	60·1	3–6
Pukapuka, Cook Is.	2·7	4·7	3·8	4·3	2·0	1·7	1·7	0·6	1·6	1·5	4·5	2·7	31·8	7
Aitutaki, Cook Is.	3·0	3·2	6·8	4·2	3·0	1·0	1·0	1·2	0·8	1·4	1·6	4·4	31·6	5
Apia, Samoa	3·5	2·7	3·1	2·6	1·6	1·2	0·4	0·3	0·8	2·3	2·8	3·7	25·0	17
Suva	6	6	7	4	2	2	1	1	1	1	2	5	38	20

Based on (1) U.S. Hydrographic Office, 'Climatic Features of the Pacific Islands Region', *Naval Air Pilot*, no. 184 (*Pacific Islands*), p. 63; (2) G. Schott, 'Klimkunde der Südsee-Inseln', *Handbuch der Klimatologie*, Band IV, Teil T, p. 104 (Berlin, 1938).

Chapter IV

SOILS

Soil Development : Soils and Natural Vegetation : Soils and Agriculture : Soil Erosion : Bibliographical Note

The soils of the Pacific islands are very varied, and important differences exist between those of the 'high' and those of the 'low' islands. In the 'high' islands, especially those which are volcanic, there are often marked differences between the soils of neighbouring areas, both in appearance and in agricultural productivity. There are however certain characteristics, which, speaking very generally, may be said to be shared by most of them. In the first place, they are often loamy or clayey in texture and may become extremely sticky and slippery when wet. In colour they are generally red (a feature which may be noticed in Gauguin's paintings of Tahiti) or yellowish, though in some places the prevailing colour is dark or even blackish. Even in the luxuriant rain forests of Samoa and New Guinea the layer of dead leaves is so thin that the bare surface of the soil often shows through ; the percentage of humus actually incorporated in the surface layers is also small. Besides these visible characteristics, others no less distinctive are shown by chemical analysis. The content of lime and other bases is generally small and in consequence the soil has an acid reaction. Often there is a deficiency in plant nutrients in general. Contrary to what might be expected from the luxuriant vegetation, Pacific soils are by no means always exceptionally fertile.

These features are characteristics not only of the soils of the Pacific islands, but of the moist tropics generally, and to understand why this is so it is necessary to know something about soil development.

Soil Development

Soils are formed by the breakdown or weathering of rocks or other mineral materials, a process which is long and complicated. Climate and parent materials, the plants and animals living in the soil or on its surface, as well as topographical factors such as slope and drainage, all play a part in determining its speed and final result. All these factors are interconnected ; now one, now another, seems

to play the leading part and we are compelled to regard all of them as forming a single very complex system in which no one factor can change without affecting the others. Because the parent rock is only one among a number of factors determining the nature of the soil, a soil map by no means coincides with a geological map; the soil map shows a relation as close or closer to a map of climate or natural vegetation.

Weathering of rocks is of two kinds, mechanical and chemical. In mechanical weathering the rock or other material is split into finer particles by agencies such as frost and sudden changes of temperature. Except on the summits of the highest mountains, frost is unknown in the Pacific islands and diurnal and seasonal temperature changes are usually slight. Such mechanical disintegration as there may be is brought about by small burrowing animals and plant roots which insert themselves into cracks and so split the rocks apart. As in all tropical countries the breakdown of rocks is brought about mainly by chemical changes and in these rain water, with carbon dioxide in solution, plays the chief part.

The most important soil-forming materials in the 'high' islands of the Pacific are volcanic deposits, lava, pumice and ash, and in New Guinea and the neighbouring large islands, old igneous and sedimentary rocks. To a much smaller extent soils are formed from transported materials such as alluvium, wind-blown dust, and wind-blown sand. In all these materials the main constituents are complex silicates which can be hydrolyzed by water into less complex substances, such as simple bases, silica, alumina, kaolin (hydrated aluminium silicate), and iron oxides. These products, in their turn, undergo further changes, while some constituents of the parent rocks, such as quartz (not abundant in most rocks of the Pacific islands) remain unaltered, or weather extremely slowly. Rain water can thus be said to act as a solvent on the rocks, though strictly speaking it first converts certain of their constituents from an insoluble to a soluble form and then dissolves them.

From a geological point of view, weathering is a very rapid process, but by the human time-scale it is slow. Since the most important processes involved are chemical, the rate depends largely on temperature. In a hot climate, like that of the lowlands of the Pacific islands, where the soil temperature is about 77° F. at a depth of a yard and varies very little, soil formation goes on very much faster than in a temperate climate such as that of Europe or of the high mountains of Hawaii and New Guinea.

Even after a soil has come into existence, weathering still continues. Like an organism the soil develops and we can speak of it as being young and immature, or old and mature. The measure of its age is, however, not its actual age in years, but the degree to which weathering has advanced, or the amount of weatherable material remaining in it. Two soils of the same actual age may be at very different stages of maturity. In islands such as Samoa, where there are lava flows of many different ages, there are excellent opportunities of comparing soils of different degrees of maturity derived from similar parent materials under similar climatic conditions.

Apart from temperature the climatic factors most influencing soil development are rainfall and evaporation, or rather, the ratio of rainfall to evaporation. When rainfall exceeds evaporation, as in the wet zones of the Pacific islands, and provided that the soil is sufficiently porous, the movement of water in the soil must be mainly downwards, the excess draining away to streams and rivers. The descending water current consists of rain water—that is, water with air, including carbon dioxide and nitrogen compounds, in solution. As the water passes down it takes up organic matter from the dead plants and animals at the surface, becomes richer in carbon dioxide, and dissolves small quantities of salts. This very dilute solution acts on the rock beneath. Thus in a wet climate there is a slow but unceasing trend towards soil impoverishment, which becomes much faster when the natural forest cover is removed to make way for cultivation. In Samoa the coconut and cocoa plantations, especially on the more mature soils, already show a slight but significant fall in productivity, which is probably largely due to loss of plant nutrients from the soil. The comparative fertility of the volcanic islands generally is due to the prevalence of young little-weathered soils.

The primary products of weathering are removed in order of their solubility. The bases begin to go first because they are the most soluble constituents ; they are washed from the upper into the lower layers of the soil and are eventually carried away with the drainage water, though for a while they may be retained by adsorption on humus or other colloidal substances such as clay particles ; the soil in consequence becomes more and more acid in reaction. Later the silica, alumina and iron oxides may follow suit, but the order in which they are removed depends largely on the amount of organic matter carried in the soil water. In water containing large amounts of organic matter, alumina and iron oxides are more soluble than

silica, thus silica remains behind and alumina and iron oxides are carried down into the deeper layers. Under these conditions the mature soil consists largely of silica and owing to the loss of iron oxides, to which most soils owe their colour, it often has a bleached or whitish appearance. In water containing little or no organic matter silica is more soluble than alumina and iron oxides. Silica is therefore carried down while, as the soil matures, it tends to consist more and more largely of alumina and iron oxides, the latter giving it a red, yellow or brown colour. The process by which alumina and iron oxides are removed preferentially, leaving silica behind, is called *podzolization*; the opposite process is *laterization*. The soils ultimately resulting from these processes are respectively called *podzols* and *laterites*. Laterites are bright red rock-like soils consisting of little more than alumina and iron oxides. They are highly infertile, but fortunately do not seem to be of common occurrence, at least in the Pacific islands. Generally the process of laterization stops short of true laterite and then the mature soil is termed *lateritic*. The progress of laterization can be measured by determining the ratio of silica to alumina and iron oxides in the clay fraction of the soil.

The amount of organic matter in the soil water, which thus has such an important effect on soil development, is mainly a function of temperature. In a well-aerated soil dead leaves and other organic remains are acted on by fungi and bacteria which gradually convert them to a mixture of substances, usually black or brown in colour, known as humus. In course of time the humus itself is attacked and converted mainly to carbon dioxide and water, any mineral matter in it being set free in the soil. The amount of humus in the soil depends on the balance between the rate of formation and the rate of breakdown of organic matter. The relative speed of the two processes depends on the temperature. Where it is high, as in tropical lowland soils, plant growth is rapid and dead plant remains are added to the soil in great quantities; on the other hand, the high temperature also accelerates the action of micro-organisms so that the plant remains are broken down as fast as they are deposited. It is found that at a temperature of 77° F. or higher, under conditions of good aeration, the breakdown processes overtake the formation of organic matter; in practice this does not mean that there is no humus at all, but the quantity is relatively small. Below 77° F. the rate of production of organic matter exceeds the rate of breakdown and humus tends to accumulate.

What has just been said is true only as long as the soil is well aerated. When it is badly aerated, that is to say, when there is a deficiency of oxygen, as when the soil is waterlogged, the activity of the micro-organisms is hindered and humus may accumulate even at temperatures over 77° F. This is especially liable to happen when the ground water is exceptionally poor in lime and other bases, as when it drains rocks init ally very poor in these substances. In the lowlands of New Guinea under such conditions humus may accumulate to such an extent that layers of peat are formed, sometimes many feet thick.

In the lowlands of the Pacific islands, then, except in certain types of swamp, the soil contains very little humus and the descending current of soil water will be deficient in organic matter. If this is so, s lica, as has been shown, will be removed preferentially to alumina and iron oxides; the dominant soil-forming process will be laterization. This is well shown in Samoa where the percentage of silica falls from over 20% in the younger soils to under 3% in the older. The lateritic soil formed under a high and well distributed rainfall is known as a tropical red earth. This is the characteristic soil type of most of the region of the earth in which the natural vegetation is tropical rain forest (p. 136). Where the rainfall is particularly heavy and there is practically no dry season, lateritic soils are found which are yellowish or brownish rather than red; these soils do not differ chemically from the tropical red earths, except in the higher degree of hydration of the iron oxides. In some places where the colour of the soil would be expected to be red it is masked by special constituents; thus in Oahu (Hawaiian islands) the soil is purplish owing to the abundance of manganese.

In the higher mountains of New Guinea and the Hawaiian islands, and doubtless on a smaller scale in the higher parts of the other 'high' islands, there are areas in which the mean annual temperature is less than 77° F., so that humus accumulation becomes possible and podzolization becomes the chief soil-forming process. Podzols, similar to those found in other cool moist climates, for instance in northern Europe, are found in the mountains of New Guinea—e.g., in the upper Ramu valley (approximately 9,000 ft.)—and similar soils probably occur in Hawaii. These soils are naturally acid and very poor in plant nutrients; this, in addition to their inaccessible situation, makes them unsuited for the cultivation of ordinary crops. Where there is a combination of low temperatures and bad drainage, as in the Alakai swamp on Kauai (5,000 ft.) and on other 'summit

bogs' of the Hawaiian islands, peat accumulates, as in some lowland swamps.

So far we have considered only those parts of the 'high' islands where there is a heavy rainfall, and where the yearly total greatly exceeds that lost by evaporation. In the dry zones of Fiji and the Hawaiian islands, and probably in New Caledonia and the dry areas of New Guinea, conditions are very different. There is a low rainfall, in some places well under 30 in. per year, and it is probable that for at least a large part of the year evaporation exceeds precipitation. This entirely alters the conditions for soil development, as there is no longer the continual downward stream of water in the soil and the tendency for soluble substances to be removed is much less. The resulting soil is red to brown in colour : it is much richer in bases than the wet zone soils and is therefore neutral or alkaline in reaction. The so-called 'reddish brown' and 'red desert' soils

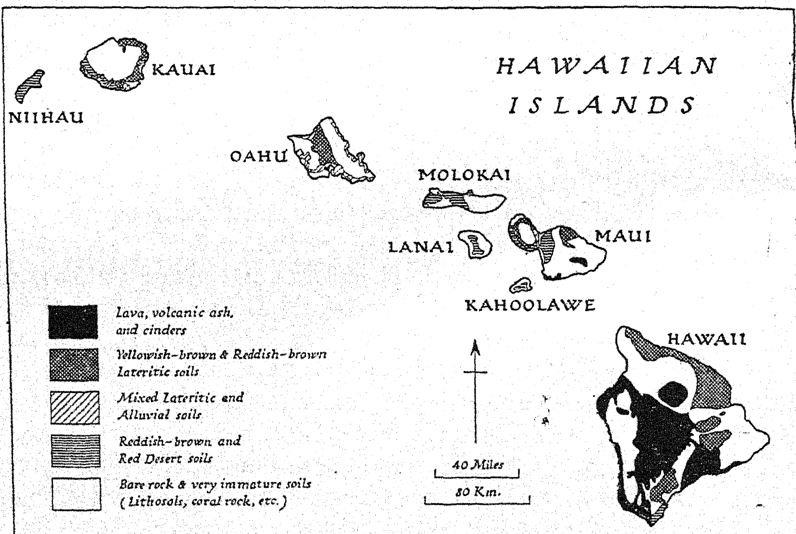

Fig. 51. Soil map of the Hawaiian islands

Based on *Soils and Men* (*Year Book of the U.S. Department of Agriculture*, 1938), *end paper* (Washington, 1938).

of the dry zones of the Hawaiian islands (Fig. 51) actually contain visible particles of calcium carbonate. The agricultural possibilities of such soils are usually limited by lack of water, but when irrigated they may prove fertile. Fig. 51 may be compared with land utiliza-

tion maps of individual islands (vol. II, Figs. 104–9), and the distribution of lateritic, mixed lateritic and alluvial soils, and reddish-brown and red desert soils, with the map of irrigated areas in the same group (vol. II, Fig. 103).

In the coral islands soil development has been little studied. Here the climate is in general drier than in the 'high' islands and

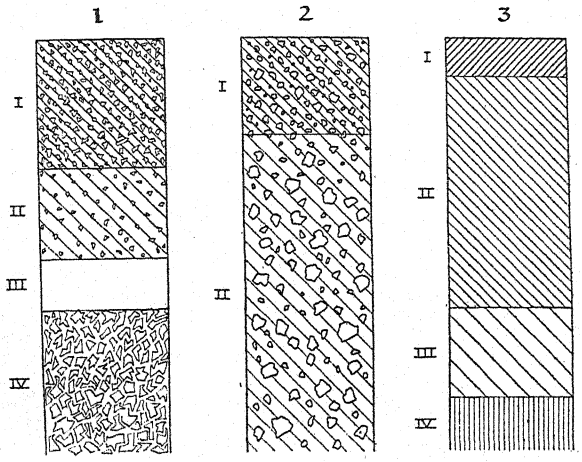

Fig. 52. Immature and mature soil profiles in the Pacific islands

1. Fanning island, central equatorial islands. An immature soil, formed under a moderately wet climate; parent material, coral limestone. I, 0–10 in., dark brown soil mostly composed of coral and shell fragments of average diameter 0.4–0.6 in.; II, 10–17 in., light brown soil mostly composed of coral fragments of average diameter 0.2 in.; III, 17–21 in., white hard pan of calcium carbonate of variable depth and thickness; IV, 21 in., white coral fragments.

2. Saleimoa, Western Samoa. An immature soil formed under a wet climate; parent material, volcanic rock (young lava flow). The soil is stony, but fairly deep and is agriculturally productive. I, 0 to 6–9 in., dark yellow-black-brown stony loam with good crumb structure; II, 9 in., dark red-brown-yellow, very free stony sandy loam. Soil reaction neutral at all levels.

3. Tiai, Western Samoa (altitude 2,250 ft.). A mature soil formed under an excessively wet climate; parent material, volcanic rock (old lava flow). A deep soil, but much less fertile than 2. I, 0–3 in., black-brown-yellow sticky clay loam, acid in reaction (pH 4.9); II, 3–21 in., dark brown-orange sticky clay loam; acid in reaction (pH 5.8); III, 21–27 in., compact dark yellow clay loam; IV, 27 in., reddish brown compact clay loam.

Profile 1 is after E. Christophersen, 'Vegetation of the Pacific Equatorial Islands', *Bernice P. Bishop Museum Bulletin*, no. 44, p. 39 (Honolulu, 1927); profiles 2 and 3 are from data of W. H. Hamilton and L. I. Grange, 'The Soils and Agriculture of Western Samoa', *New Zealand Journal of Science and Technology*, vol. XIX, pp. 593-624 (Wellington, 1938).

the parent material, coral rock, is peculiar, consisting of little else than carbonate of lime. Often there is little soil of any kind, what there is being sandy or gravelly in texture and full of limestone particles (Fig. 52). The tendency to loss of bases is less important here, but the thinness of the soil and its excessive porosity make it unfavourable for plant growth. On Manihiki (Cook islands) the inhabitants even find it worth while to import soil by schooner from Rarotonga for vegetable growing. Where the climate is wet and has had long enough to operate, as on Niue, an upraised coral island, a yellowish brown lateritic clay soil is developed, which though rarely more than 6 in. deep, is not essentially different from soils developed from other parent materials under similar climates.

Soils and Natural Vegetation

In England and many other parts of the world the correlation of soil and natural vegetation is so close that the vegetation is generally a sure index to the type of soil. In tropical countries the influence of soil on natural vegetation is less striking, though each of the main types of soil is associated with a type of vegetation—for instance, tropical red earths with tropical rain forest, podzols with montane rain forest. The reason for this is not difficult to understand ; the influence of the climate is so powerful that it tends to over-ride differences of soil due to different parent rocks. The importance of soil in determining the type of natural vegetation in the tropics, must not, however, be under-estimated. In the Pacific islands the correlation of soil and natural vegetation has been little studied, though the difference in vegetation between volcanic and limestone areas is obvious to anyone, especially in islands like some of the Fiji group where limestone and volcanic rocks are found side by side. Other examples of the influence of soil on vegetation will no doubt be shown by more detailed studies in the future.

Soils and Agriculture

When the natural vegetation is destroyed and replaced by an agricultural crop differences of soil which showed little effect on the natural vegetation may take on great importance. The appreciation of these soil differences and their effects may therefore decide the success or failure of the crop. To understand why this is so, it is necessary to consider the relation of vegetation to soil a little more closely.

Plate 32. Beach vegetation, Mangareva
This view shows the summit of the coral rubble dam formed from the eroded reef flat.

Plate 33. Vegetation of Baker island
This shows the typical vegetation of a coral island in the central equatorial area. The plants are *Lepturus repens* (a grass), *Boerhaavia tetrandra* and *Portulaca lutea*.

Plate 34. Undergrowth of tropical rain forest in the interior of Bougainville, Solomon islands
The palm in the centre is *Licuala polyschista.*

It is a remarkable fact, and one which is very disconcerting for the agriculturist, that a soil which under natural conditions bears a luxuriant rain forest, when cleared and cultivated may give good crops for only a very few years, or may prove a failure from the start. The explanation lies in the fact that the plant nutrients, such as salts containing calcium, phosphorus, potassium, etc., on which soil fertility largely depends, constantly circulate between the plants and the soil. These plant nutrients, as has already been shown, are among the most soluble products of weathering and therefore the most easily lost. In a damp climate the descending water currents in the soil continually tend to wash these soluble materials from the upper to the lower layers of the soil, where they may be out of reach of the plant roots. Eventually they are lost in the drainage water. Where there is a covering of natural vegetation, for instance a tropical rain forest, a large proportion of these nutrients are taken up by the plant roots immediately after they are set free by weathering. Part is also held by adsorption on the humus and colloidal clay particles. When the plants shed their leaves or die, their dead remains are converted to humus and the mineral nutrients are again set free in the soil. There they are immediately taken up again by plant roots or adsorbed by colloids. Thus after they are liberated from the rocks the mineral nutrient substances are always circulating from soil to plant and back again. Only a small amount is lost in the drainage water and this is made good by fresh supplies set free by weathering. There is thus a nearly perfect equilibrium between vegetation and soil, an illustration of the statement made earlier that plants and soil form parts of a single interconnected system.

When the forest is cleared to make way for cultivation this equilibrium is suddenly upset. The felled trees are either burnt or left to rot. Their remains are rapidly converted to humus by micro-organisms and the humus itself is broken down to carbon dioxide and water. When the soil surface is exposed to the direct rays of the sun, its temperature rises and the breakdown of organic matter is so accelerated that the small amount of humus previously present in the soil soon disappears. The net result of all this destruction of organic matter is that most of the mineral matter which was safely locked up in living plant tissues and in the humus is suddenly set free. As one writer puts it: 'The entire mobile stocks of mineral nutrients are put into liquidation and, as is usual at a forced sale, they go at give-away prices and the advantage reaped is by no means commensurate with their value.' The sudden release of mineral

matter may mean that very good crops can be obtained for a few seasons, but as the minerals are gradually washed away by the rain and removed in the crops the soil becomes less and less fertile until it becomes unprofitable to cultivate.

It is easy to understand why the native agriculturist prefers the extremely destructive system of shifting cultivation in which only a very few crops are taken off the same piece of ground. Much European agriculture in the tropics has been little more permanent; the forest has been cleared, the mineral capital of the soil consumed in a very few years and then the land has been abandoned. Many agricultural areas in the Pacific islands, including large parts of Fiji, Samoa and Hawaii, appear to be able to maintain their fertility for long periods, apparently indefinitely. This fortunate state of affairs is due, as we have seen, to the presence of young soils still rich in weatherable materials from which calcium, potassium and other plant nutrients can still be released. In some plantations in Samoa, especially on the more mature soils, there has been already a slight but significant fall in productivity which is probably due to the loss of plant nutrients from the soil. This loss of nutrients goes hand in hand with laterization and it has been found that crop yields are in direct proportion to the percentage of silica in the soil.

The European agriculturist has the advantage over the native in that he understands the use of fertilizers and within limits can compensate the natural deficiencies of the soil. Soil research in the Pacific islands has been mainly concerned with detecting and measuring mineral deficiencies in agricultural soils in order to apply fertilizers in the most economical way. One of the most common needs of Pacific soils is lime, and liming, often given in the form of dressings of coral sand, is a standard method of treatment. Lime has a number of different effects on the soil; it releases potassium and other bases by the process of base exchange, it improves the texture of many soils and it neutralizes acidity. With lime, as with other fertilizers, the treatment has to be suited to the requirements of the particular crop. Most tropical crops grow better on neutral or slightly alkaline than on acid soils; the banana, for instance, becomes liable to Panama disease under acid conditions. Tea, however, likes an acid soil and is injured by liming. Even when the fertilizer requirements of a soil are known, problems may remain. For instance, Hawaiian soils have a remarkable power of fixing phosphate fertilizers, that is, they convert them into a form in which they are not readily available to plants.

Soil analysis sometimes reveals the presence in the soil of constituents poisonous to plants, the ill effects of which can be neutralized by suitable fertilizers. Thus on some very acid Hawaiian soils crops are sometimes injured by the toxic effects of iron and aluminium. The soils of Samoa contain abnormally large amounts of chromium which is known to be toxic to plants; it has however been shown that the chromium is in an 'unavailable' form and it is therefore unlikely that it causes any damage.

Soil Erosion

One of the chief problems of soil utilization is that of soil erosion. Under a covering of natural vegetation the soil is protected, but when the land is cultivated the surface is exposed to erosion by rain and wind. The finer particles of soil may be carried away so that the texture of the soil becomes more and more sandy, or the top soil may be removed bodily, together with its humus and other valuable constituents. In extreme cases the whole of the soil may disappear, leaving only the bare rock. Often the land becomes carved into deep gulleys down which floods pour during storms, spreading mud over roads and flat land. Though generally erosion is economically disastrous, it occasionally has compensating advantages. Thus on the Ewa sugar plantations, on Oahu, 200 acres of new and fertile cane land have been built up by leading flood water containing soil washed off the hills through specially constructed drains on to the coral plain; $3\frac{1}{2}$ in. of new topsoil have been spread over 140 acres on which cane previously grew badly owing to the thinness of the soil.

In the Pacific islands, with their steep slopes and heavy rainfall (much of it in the form of torrential downpours), conditions might be expected to favour erosion, but for a number of reasons damage has not so far been as serious as in many other parts of the world, though in limited areas it has been catastrophic. In the Hawaiian islands there has been great damage in some places; on the island of Kahoolawe, for example, almost all the soil has been lost, mainly by wind erosion of soil exposed by overgrazing. In Fiji much erosion has taken place—in the Kaloba area of Viti Levu 2 ft. of soil have been lost in five years—but erosion is not as yet a major problem. Overgrazing has led to disastrous erosion in the Marquesas, notably on Eiao, where after heavy rain streams of muddy water pour into the sea, carrying away hundreds of tons of soil.

The speed and extent of erosion depend on many factors. Besides the slope and the quantity and character of the rainfall, the texture of the soil itself is important. Hawaiian soils are mostly so permeable that the rain quickly penetrates and there is little run off, hence there is much less erosion than might be expected. The underlying rock is also a factor; thus the soapstones of Fiji are slippery when wet, so there is a tendency for the whole mass of soil to slide off.

The nature of the soil covering is of great importance. Different crops and methods of cultivation make a great difference to the amount of erosion. In the sugar-cane fields of Hawaii, for instance, there is comparatively little erosion, because the cane plants tend to hold and protect the soil and because the soil is loosened only when it is deeply ploughed, once in 10 to 12 years. Pineapple cultivation, on the other hand, is more harmful. The cover is less good and it is a common practice to plough the land in straight lines which may run perpendicular to the contours, so that the furrows form channels for flood water; also the land is cultivated in three-year cycles, with fallow periods of 6 to 9 months between, during which erosion has free play. Grassland is subject to erosion only if it is too heavily grazed and the grass covering wears thin. In many of the Pacific islands erosion has resulted from overgrazing by domesticated animals such as sheep and pigs which have run wild.

Though soil erosion has not yet become an urgent problem in most Pacific islands, it is likely to become so very soon, as the amount of agricultural land is not large in relation to the needs of the population. Only in the Hawaiian islands have energetic steps been taken to check erosion. Among the more important measures that can be adopted are changing from straight-line ploughing to ploughing along the contours, using a rotation of crops so as to eliminate a fallow period, and reducing the overstocking of pastures, so that each area of grassland can be 'rested' in turn. Where the covering of plants has been destroyed a new cover can be provided: in Hawaii the introduced *algaroba* tree (*Prosopis*) and certain grasses have been very useful for colonizing badly eroded land. Where gully erosion has taken place channels for controlling the run-off must be made, check-dams constructed and trees planted on denuded areas.

Erosion control involves difficult problems of administration and agricultural education. It is greatly affected by the system of land tenure. Where the land is cultivated by a tenant who can easily

move to fresh ground when the productivity of the soil is exhausted there is no incentive to troublesome measures of soil conservation. In Hawaii, when public land is leased to stockmen, it is now customary to insert a clause in the lease requiring the tenant to remedy and prevent soil erosion.

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A Handbook on Hawaiian Soils by W. W. G. Moir and others (Association of Hawaiian Sugar Technologists, Honolulu, 1935) is a comprehensive account of the soils of the Hawaiian islands, mainly in relation to sugar-cane cultivation; it has a full list of literature up to the date of publication. In addition mention should be made of E. C. J. Mohr, 'Tropical Soil Forming Processes and the Development of Tropical Soils, with special reference to Java and Sumatra' (mimeographed translation by R. L. Pendleton), *College of Agriculture, University of the Philippines, Experiment Station Contribution*, no. 655 (Manila, 1930), much of which is applicable to the soils of the Pacific islands.

Chapter V

VEGETATION

General Features : Types of Vegetation : Coastal Vegetation : Vegetation of Coral Islands : Vegetation of ' High ' Islands : History of the Vegetation : Notes on Some Common Plants : Bibliographical Note

The islands of the Pacific enjoy a tropical, or at least a sub-tropical, climate and for the most part have the perennially green, almost overpoweringly luxuriant vegetation characteristic of the wet tropics. The leeward Hawaiian islands in the north, Juan Fernández, Easter island, the Kermadec islands, etc., in the south, lie, it is true, well outside the two tropics, but their climate is so nearly tropical that their vegetation is not fundamentally different from that of the islands nearer the equator.

GENERAL FEATURES

So far as plants are concerned, the chief features of a tropical climate are a constantly high temperature, with little seasonal change, combined with abundant rainfall well spread through the year. Under such conditions plants can grow and reproduce at all seasons, and where the natural vegetation has not been modified by man and his domestic animals, forests of evergreen trees are the rule. In some parts of the Pacific, e.g., the drier parts of New Guinea and Easter island, the present-day vegetation is not evergreen forest, but grassland or savannah ; it is probable, however, that here too there was forest in the not very distant past. In the serpentine region in New Caledonia there is much low scrub in which trees apparently cannot grow ; this seems to depend on a combination of a porous soil with a comparatively dry climate. Nowhere in the Pacific islands are there deciduous forests shedding their leaves regularly in the dry season like the teak forests of Burma and the south-eastern Malay archipelago.

Though the vegetation of the Pacific looks much the same at one time of year as another, many of the plants show slight seasonal changes. In Samoa, for instance, where there is a difference of only a little more than 2° F. between the mean temperature of the hottest and the coldest month, many of the trees have definite flowering seasons. In the New Hebrides and Tikopia, the flowering of

Plate 35. Tropical rain forest, Gazelle peninsula, New Britain
The large trunk in the centre is *Eucalyptus deglupta*, a giant gum tree which forms the top storey of the forest in this area.

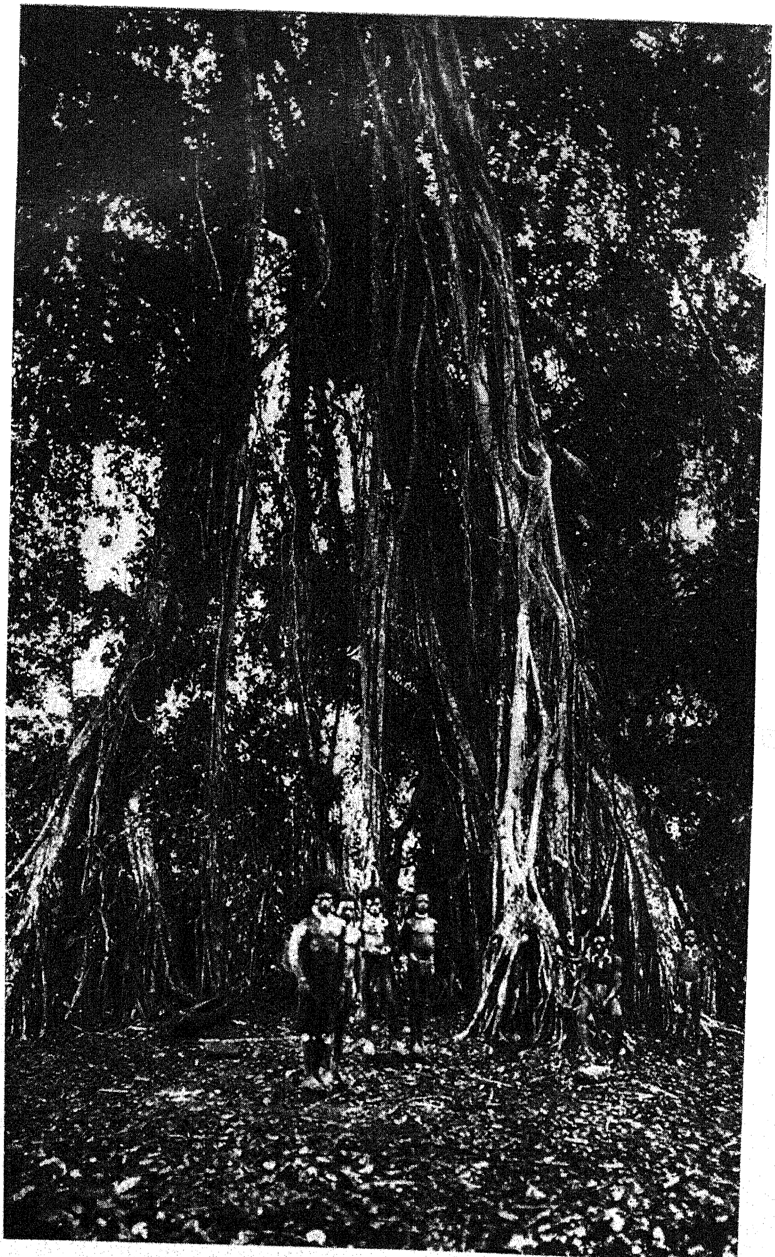

Plate 36. Banyan fig (*Ficus chrysolaena*)
This specimen is from Ragetta island, near Madang, New Guinea.

Erythrina indica tells the natives when to plant their yams. Though there are no deciduous forests, many individual species of trees shed their leaves at regular or irregular intervals.

Apart from the tropical climate the chief factor in the Pacific which has influenced the vegetation is the fact that the land area is composed of a large number of widely separated islands, varying in size from almost continental New Guinea to tiny reefs and atolls on which a handful of plants maintain a precarious foothold. Since for most plants it is much more difficult to spread across wide stretches of sea than across the land, the isolation of the Pacific islands has had important consequences for their plant life. In the first place, though it would be difficult to give even an approximate estimate of the number of plant species in the Pacific islands, there is no doubt that, if the great island of New Guinea is excluded, the total flora is poor compared with that of the other great tropical regions. The flora of individual islands or groups is not large even by European standards; compared with similar areas in Malaya or tropical America it is extremely small. Thus New Caledonia has about 2,300 species of flowering plants and the Hawaiian islands about 850, compared with some 1,500 in the British Isles and over 10,000 in Borneo.

A second consequence of isolation is the large number of endemic species, that is, species found only on a single island or group of islands, as for instance the palm *Juania australis* found only on Más-á-tierra (Juan Fernández) and the remarkable tree *Fitchia* which is found nowhere in the world except in Rarotonga and the Society islands. Some endemics are believed to be newly evolved species which have not yet had time to spread, others are probably very old species which have died out everywhere but where they are now found. A high percentage of endemic plants and animals is characteristic of remote islands and isolated mountain tops. In New Caledonia about 77% of the flora is endemic, in the Hawaiian islands about 70%, though in most of the high islands the proportion of endemics is not as high.

The Pacific islands are so varied in character and are spread over so large a part of the earth's surface that their vegetation would also be expected to be extremely varied. On the whole, however, the differences in the vegetation between one part of the same island and another are often more striking, at least to the non-botanist, than those between very widely separated islands. For example, nothing could look more different than the sun-baked grasslands

on the leeward side of Viti Levu in Fiji and the permanently moist evergreen forest on the windward side. On the other hand the vegetation of two atolls thousands of miles apart may be extremely similar, and the rain forest of Juan Fernández is not very different at first sight from that in the Kermadecs, some 6,000 miles away. In general, as in the examples just given, differences or resemblances in vegetation depend on difference or similarity in total rainfall, though in New Guinea and Hawaii where there are mountains reaching the region of perpetual snow, or very nearly so, there are striking altitudinal differences in vegetation depending on temperature as well as rainfall.

In all the inhabited islands, in addition to the native plants, there are introduced species brought in by Europeans or by the native inhabitants. Some of these introduced species are cultivated plants, many of which have run wild and maintain themselves unassisted; others are weeds introduced unintentionally. The introduced flora has often proved aggressive and ousted the native flora over large tracts of country. Thus at low altitudes in the dry zone of Oahu in the Hawaiian islands the introduced plants have almost completely exterminated the native flora, and in many Pacific islands the visitor could spend a long time without seeing a single truly native plant. Usually, but by no means always, the native and the introduced floras do not mix, but occupy separate areas.

Broadly speaking the native flora of the Pacific islands (except that of groups like Juan Fernández and the Galápagos, which lie close to the coast of America) consists mainly of species which are either identical with species of the Indo-Malayan region (south-eastern Asia and the Malay archipelago), or are closely related to such species. There is thus good reason for believing that the majority of Pacific island plants or their immediate ancestors immigrated at some period from the west.

Though the flora of the Pacific has mostly come, recently or in the very distant past, from elsewhere, it is not without its peculiar forms of plant life, some of which are as remarkable as those found in any region of the earth and are very different from anything known elsewhere. The first place among these must certainly be given to the grotesque tree *Lobelioideae*, most of which are confined to the Hawaiian islands. These plants are related to the small blue *Lobelia* of English flower beds, but here they are trees, in some species 35 ft. or more high. The long narrow leaves are usually borne in a tuft at the tip of the otherwise bare branches, together

with the showy blue, purple or whitish flowers. Mention should also be made of the araucarias (related to the Chilean monkey-puzzle of English gardens), and other peculiar conifers of New Caledonia and New Guinea. One of these, *A. columnaris* (*A. Cookii*) gave its name to the Isle of Pines, and the appearance of the tall unbranched trunks is so odd that when the botanist Forster saw them from his ship on Cook's famous voyage he mistook them for basalt columns (Plate 48).

As well as these plants, which are not native outside the Pacific, there are some other remarkable-looking plants which the Pacific shares with other parts of the tropics. There are, for instance, a wealth of tree ferns and palms, the screw pines (*Pandanus*) with their queer twisted appearance and cone of prop roots (Plate 52), and the banyan figs, vast trees with a wide-spreading crown supported on a mass of descending aerial roots (Plate 36). In New Guinea, the Carolines and New Caledonia are found the curious and beautiful insect-eating pitcher plants, *Nepenthes*. *Myrmecodia*, an extraordinary plant with a swollen stem inhabited by ants, is common in the mountains of New Guinea (Plate 47).

Some Pacific plants, but not many, have been introduced into cultivation and carried to distant parts of the world. One example is the palm *Howea Belmoreana* which ornaments nearly every cinema and hotel lounge in Europe and North America; it is an endemic, native only in Lord Howe island, where collecting the seeds is the staple industry of the inhabitants. Another is the graceful Norfolk island pine, *Araucaria excelsa* (Plate 53), young plants of which are one of the commonest window decorations in English houses.

TYPES OF VEGETATION

In considering the types of vegetation in the Pacific islands a sharp distinction must be made between the 'low' islands—atolls and reefs of coral raised only a few feet above sea-level—and the 'high' islands, which are volcanic and frequently reach a height of 3,000 ft. (or much more). The 'low' islands are poor in species, very uniform in flora, and the vegetation consists largely of maritime and drought-resistant plants. The 'high' islands—and with them may be grouped New Guinea and other large islands of the Western Pacific—have a far richer and more varied vegetation. The coral islands are so small and so little raised above the sea that practically

all their vegetation is affected to some extent by salt water; it is thus hardly surprising that the plants which grow on them are mostly the same as those found round the shores of the 'high' islands. After dealing with the coastal vegetation of the Pacific in general, it will therefore be convenient to pass next to the vegetation of the coral islands.

Coastal Vegetation

On reefs and rocks between the tidemarks and for some depth below the low tide mark there is a rich flora of green, brown and red seaweeds. Most of the species and many of the genera are different from those familiar in England; for instance, the wracks (*Fucus* and related genera) which bulk so largely in the vegetation of our own shores are not found, the commonest large brown seaweeds being the Sargasso weed (*Sargassum*) and the related *Turbinaria*. Many of the Pacific seaweeds, especially those belonging to the group of red algae, deposit calcium carbonate, and along with the corals play an important part in reef building. In Hawaii seaweeds are of some economic importance as they are much valued by the inhabitants as food, some 75 different kinds of seaweed (*limu*) being used. The ancient Hawaiian nobility, like the modern Japanese, deliberately cultivated these plants, setting aside near their dwellings fishponds or sections of the coast to which desirable kinds of seaweed were transplanted, the unwanted kinds being weeded out.

The nature of the land vegetation of the coast depends mainly on whether the shore is sandy, muddy or rocky, as well as on the exposure to wave action. On sandy shores low-growing herbs, grasses and bushes are found (Plate 32), similar to the *strand vegetation* of Europe. It consists of a limited number of species most of which are rarely seen inland. Some of the commonest are the goat's-foot convolvulus (*Ipomoea pes-caprae*), species of *Vigna* and *Canavalia* (belonging to the pea family), *Lepturus repens* and other grasses. Except for the grasses most of these plants have a trailing or creeping growth and many have fleshy or hairy leaves. Unlike most land plants they are not killed by occasional flooding with salt water. Scattered among these low-growing plants or sometimes forming thickets or a definite belt on the landward side are found bushes a yard or more in height such as *Desmodium umbellatum*, *Pemphis acidula* and *Scaevola frutescens* (Fig. 53). In this scrub there may be occasional trees of coconut (Plate 31), the tree heliotrope,

(*Tournefortia*, Fig. 54), *Hernandia ovigera*, etc. On reefs and rocky shores there are generally scattered bushes extending as far from the shore as the influence of the spray is strongly felt, and consisting

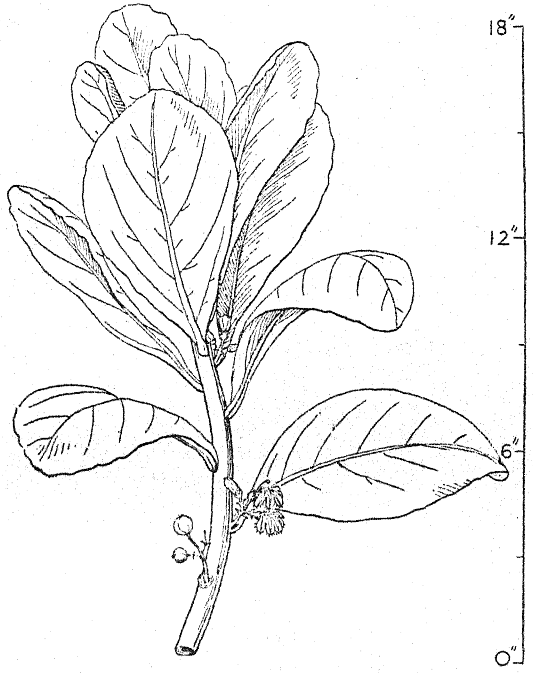

Fig. 53. *Scaevola frutescens*, sea-lettuce tree

A tree or shrub common on the coasts of most Pacific islands. The leaves are a fresh green colour and the flowers are almost white. Drawn from *Botanical Magazine*, vol. LII, plate 2732 (London, 1827).

almost entirely of species such as *Scaevola frutescens*, *Pandanus*, etc., which are also found on sandy shores.

Where the sandy beach is wide and the natural vegetation has not been destroyed, a strip of forest of very characteristic composition may develop on the landward side; this is the *beach forest*. Like the strand vegetation it is formed chiefly of species not found inland. At its best the beach forest is a narrow belt of trees 100 ft. high or more, but often it is much lower and does not form a continuous belt. Good beach forest is only seen on the less thickly populated islands, because elsewhere it is generally destroyed or reduced to a

mere vestige to make room for plantations of coconut palms. In the Solomon islands the natives like to leave the beach forest to screen their villages from unwelcome visitors coming by sea. Common trees of the beach forest are *Barringtonia asiatica* (Fig. 55),

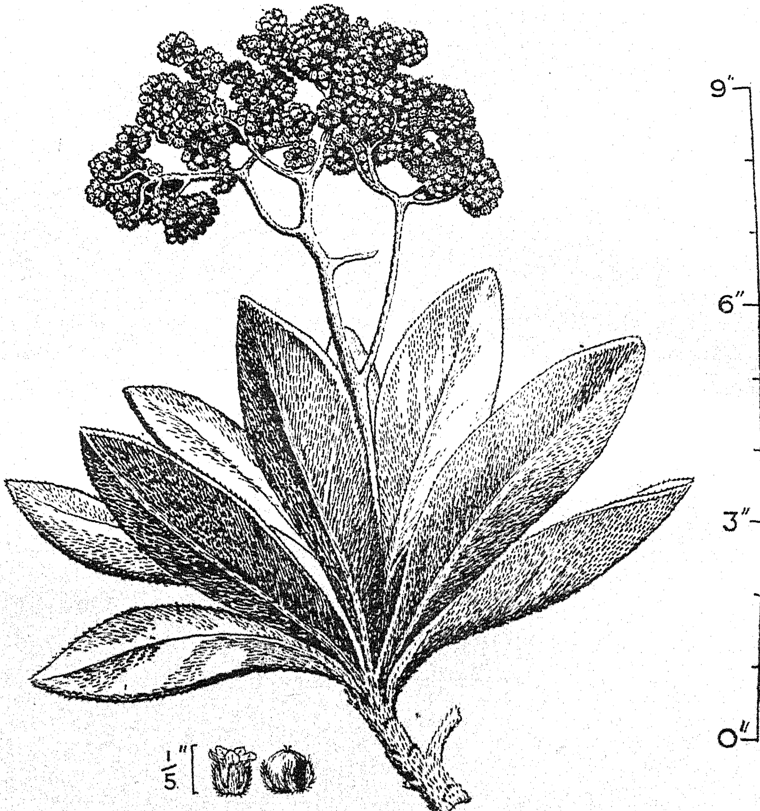

Fig. 54. *Tournefortia argentea*, tree heliotrope

A small tree common on beaches and coral islands in the warmer parts of the Pacific. The flowers are purple and the leaves conspicuous for their covering of silvery hairs. Drawn from W. E. Safford, 'The Useful Plants of Guam', *Contributions from the United States National Herbarium*, vol. IX, plate 68 (Washington, 1905).

Calophyllum inophyllum (Fig. 56, Plate 30), *Cordia subcordata*, *Hibiscus tiliaceus* (Fig. 67), *Terminalia catappa* (Fig. 57), *Thespesia populnea* and *Cerbera* species. In the Western Pacific (in New

Guinea especially near river mouths) the graceful *Casuarina equisetifolia* (Fig. 66) often forms large stands unmixed with other trees. The outer edge of the beach forest is often fringed with

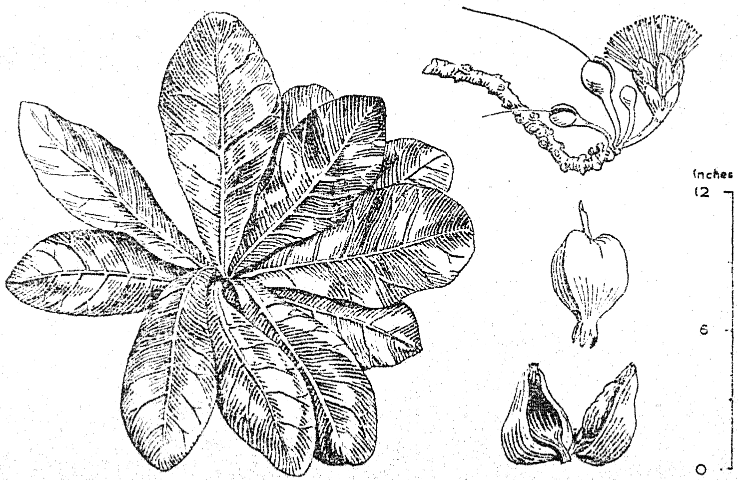

Fig. 55. *Barringtonia asiatica*

A large tree characteristic of the beach forest in the Pacific islands. The four-angled fruits are one of the most common objects in the drift. Drawn from E. J. H. Corner, *Wayside Trees of Malaya*, vol. II, plate 72 (Singapore, 1940).

Pandanus tectorius or other species of *Pandanus*. With the trees are associated shrubs, woody climbers, and herbaceous plants growing both on the ground and as epiphytes on the trunks and branches. The leafless parasite *Cassytha*, looking like a tangle of orange string, often grows over the trees and bushes in masses.

In sheltered bays, lagoons and estuaries, usually on a muddy substratum, is found the mangrove, a peculiar type of low forest or scrub flooded by the tides. These mangroves cover vast areas on the south coast of New Guinea and are also extensively developed in Fiji, New Caledonia and other islands of the Western Pacific. East of Tonga and Samoa they are not met with again till the Galápagos and the west coast of South America (Fig. 58).

Mangroves grow where the land is rising, sometimes as fast as an inch a year, by the deposition of silt. As new land is built up and consolidated, so the mangroves push out further and further into the water. By obstructing the tidal currents the mangroves speed

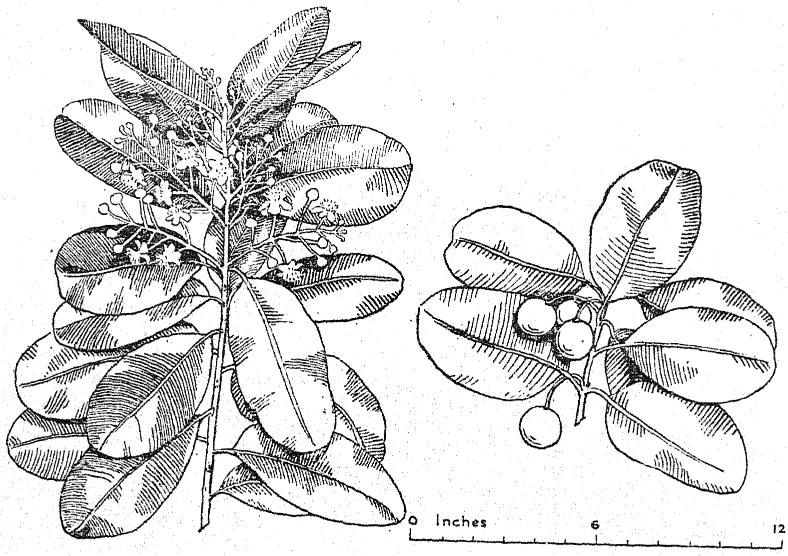

Fig. 56. *Calophyllum inophyllum*
A large tree of the sea coast, widespread in the Pacific. Drawn from E. J. H. Corner, *Wayside Trees of Malaya*, vol. II, plate 65 (Singapore, 1940).

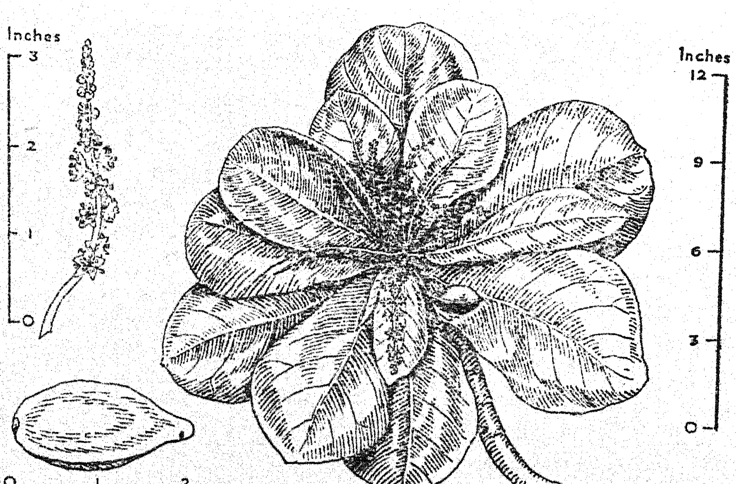

Fig. 57. *Terminalia catappa*, Indian almond, native almond
A common tree of the beach forest, also planted inland as a shade tree. Based on *Botanical Magazine*, vol. LVII, plate 3004 (London, 1830); and E. J. H. Corner, *Wayside Trees of Malaya*, vol. II, plate 45 (Singapore, 1940).

up the deposition of silt and thus play an active part in reclaiming land from the sea. They are of great economic importance for other reasons also; they provide excellent firewood and in Suva (Fiji) the whole supply of firewood for domestic and industrial use comes from the mangroves of the Rewa delta. The wood is hard and durable and is used for house building and many other purposes. The bark of mangroves is valuable for tanning, but little use has been made of it so far in the Pacific.

The mangroves are a group of trees not nearly related to each other botanically, but having certain remarkable features of structure and life-history in common, as well as the ability to grow on unstable mud periodically washed by the tide. The mangrove swamps of the Pacific are by no means so rich in species as, for instance, those of the Malay archipelago, but in addition to several species of mangrove trees, there are various shrubs, climbers, reeds and herbaceous plants, including the fern *Acrostichum aureum*. The mangroves themselves are evergreen trees varying from 10 to over 100 ft. in height. Most of them have shiny, leathery leaves

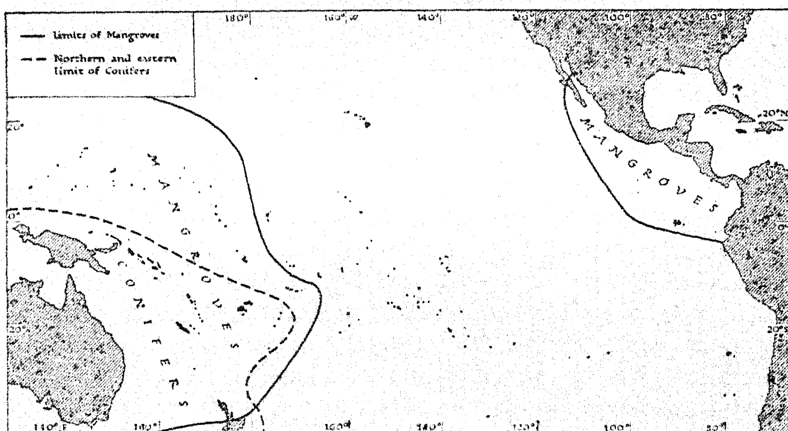

Fig. 58. Distribution of mangroves and conifers in the Pacific

All members of the mangrove group have been included. The eastern species (with one exception) are all different from those in the west of the area. Based on various sources.

and inconspicuous flowers, but the most striking features are their buttressed trunks and peculiar roots. In *Rhizophora* the trunk is supported on a mass of curved aerial roots (Plate 51), like very

slender flying buttresses. In *Avicennia* and *Sonneratia* the main lateral roots are horizontal and produce large numbers of small branches which grow vertically upwards through the mud and project several inches above the surface. These branch roots look like cigars or sticks of asparagus and beneath a large tree they are so numerous that one can hardly put one's foot between them. In *Bruguiera* the large lateral roots make a succession of upward bends or loops above the mud and are known as knee roots. The mud on which mangroves grow is almost completely deficient in oxygen and as the aerial roots of *Avicennia*, *Sonneratia* and *Bruguiera* are provided with very numerous lenticels (breathing pores), their main function was supposed until recently to be to act as aerating organs for the root system. Though they probably do this to some extent, they seem to have equal or greater importance in providing a means by which fresh rootlets can be given off at higher and higher levels as the mud accumulates. The dense growth of the aerial roots, and the softness of the mud make mangrove swamps unpleasant, but by no means impossible, to traverse.

A remarkable feature of many mangroves is that the seeds germinate before leaving the parent plant; in some they grow into a heavy fleshy seedling, as big as a small candle. When the young plant at last drops off it is heavy enough to stick firmly in the mud at low tide and anchor itself before the tide can wash it away. The seedlings of mangroves float well in sea water and may be carried by currents for some distance.

Owing to the preferences of the different species of mangroves for different conditions of tidal flooding and soil, they are not distributed at random, but are arranged in a series of belts or zones, generally running more or less parallel with the shore. In the Pacific, the pioneers which colonize the least stable and most frequently submerged muds at the outer fringe of the mangrove forest are usually species of *Rhizophora*, but at times their place may be taken by *Avicennia* or *Sonneratia*. Other mangroves, such as *Bruguiera*, requiring less frequent submergence and different soil conditions, follow when the ground has been prepared for them by the pioneers; the zonation thus represents an actual plant succession in which one group of species is superseded by another. As the pioneers are succeeded by more exacting species new land is added at the seaward edge and so the mangrove forest extends slowly out to sea. At the same time the soil level on the landward side rises and as the effect of the tides is felt less and less, the mangrove swamp with

salt ground water gradually turns into a freshwater swamp forest inhabited by quite different trees.

Associated with the mangrove swamp in the Western Pacific is a very characteristic community dominated by *Nipa fruticans,* a palm with a very short stem and feathery leaves, 20 ft. long or more. *Nipa* swamps form a very dark green belt contrasting with the lighter green of the mangroves along the sides of estuaries; they are particularly extensive along the gulf of Papua in New Guinea. *Nipa* likes brackish, not salt, conditions and unlike the mangroves it is not confined to places where silt is being deposited.

One of the most interesting facts about the coastal vegetation of the Pacific is its great uniformity throughout the whole area. Nearly all the component species have an extremely wide distribution and very few are endemics limited to small areas. The strand flora of one island is thus very like that of another, though thousands of miles away. The same is true to a large extent of the beach forest, and the reason is probably that coastal plants, unlike most inland plants, have seeds or fruits specially adapted to float in sea water by means of air cavities or spongy air-containing tissues (Fig. 59). They may thus be carried enormous distances by ocean currents and, if the conditions are suitable, may germinate when they are cast up. The mangroves differ somewhat from the other coastal plants in that all the species, though not the genera, found on the American shores of the Pacific, including the Galâpagos islands, are different from those in the Western Pacific. (The one exception is an American species of *Rhizophora* found together with the Western Pacific species in Fiji and Tonga.) This difference between the Eastern and Western Pacific mangrove floras may be due to the seedlings of mangroves not being so well fitted for long sea journeys as are more resistant seeds and fruits.

The coastal vegetation of the Hawaiian islands is exceptional in lacking many of the widespread species and in having a number of endemic species not found elsewhere. This is doubtless owing to the extreme isolation of these islands (they are distant some 2,000 miles from the nearest continent or 'high' island) and because they lie off the track of the main ocean currents.

VEGETATION OF CORAL ISLANDS

Writers of fiction are apt to represent coral islands as having a luxuriant vegetation, abounding in useful and beautiful plants. This impression is very far from the truth; a typical coral island or atoll

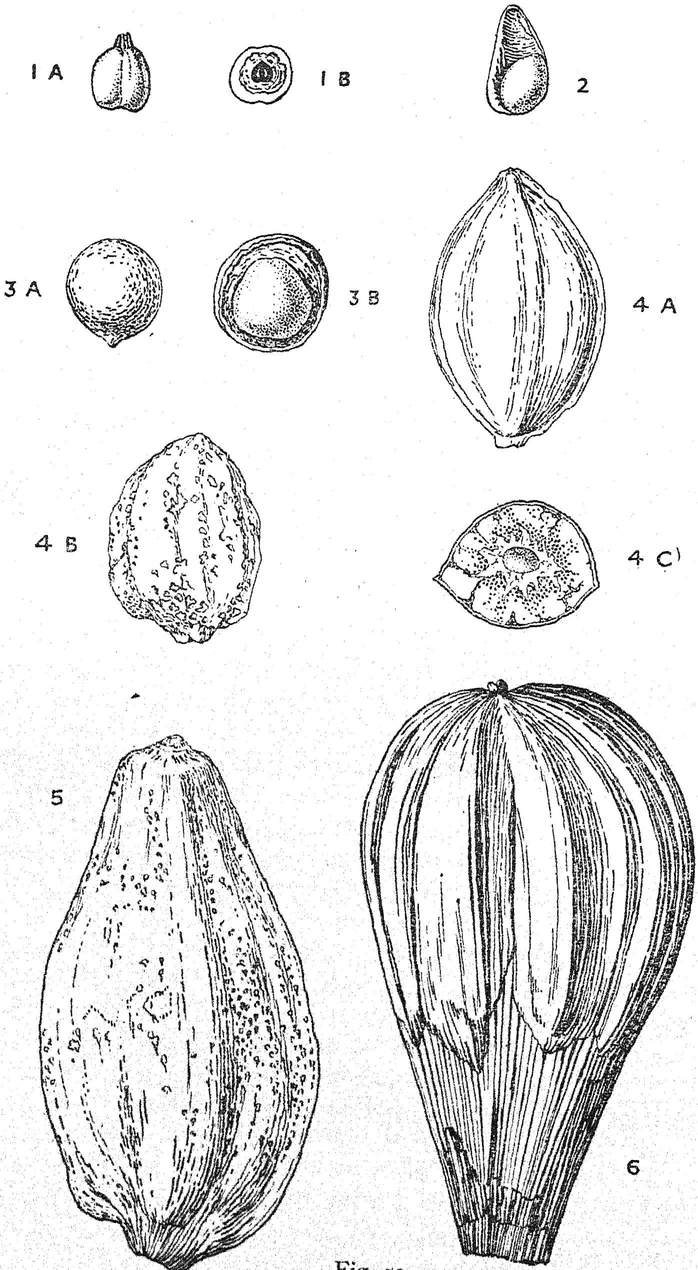

Fig. 59

has generally a poor and scanty vegetation of very few species (Plate 33). Besides the coconut palm and plants cultivated by the natives, there is often little but tufts of grass, scattered bushes and herbaceous plants. Many of the smaller islands are entirely treeless and even the larger and more fertile ones have little to show beyond woods composed of one or two kinds of trees. As far as useful plants are concerned, it is probably true to say that every food plant except the screw pine (*Pandanus*) has been introduced by man; no coral island would be habitable without the coconut, which though apparently self-supporting on some islands, was probably almost always planted in the first place.

The lack of luxuriance in the vegetation depends on the conditions for plant growth, which in the majority of coral islands suit only plants tolerant of severe droughts. (For the climate of the coral islands, see Chapter III). The effects of a low and unreliable rainfall are increased by strong evaporation and a porous soil with little power of retaining water. Besides the shortage of water, in many small coral islands the poverty of the vegetation is partly due to accumulations of phosphate which, though used as a fertilizer, is harmful to plants in large amounts.

Apart from cultivated plants, there may be as few as half a dozen species on a small island and under 50 on a large one. In a botanical survey of the central equatorial islands, comprising Christmas, Jarvis, Fanning, Washington, Palmyra, Howland and Baker islands, some 60 native flowering plants and ferns were found, in addition to about 20 introduced weeds, and a number of cultivated plants, most of which could not maintain themselves for long without human help. The flora of coral islands consists of a selection, varying slightly with each individual island, from a very limited

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Fig. 59. Pacific fruits distributed by the sea, showing means of flotation
1, *Scaevola frutescens*: A, whole fruit; B, cross-section, showing the two seeds (heavy black outline) enclosed in a corky flotation tissue (stippled), and the juicy outer layer. 2, *Morinda citrifolia*: stone of fruit with swim-bladder. 3, *Calophyllum inophyllum*: A, whole fruit; B, cross-section, showing seed surrounded by spongy flotation tissue. 4, *Terminalia catappa*: A, whole stone of fruit; B, stone worn by the sea, showing flotation tissue; C, cross-section of stone, showing numerous small cavities in flotation tissue (the seed has dropped out). 5, *Barringtonia excelsa*: fruit. 6, *Nipa fruticans*: fruit with the outer covering partly worn away and showing the fibrous flotation layer. The scale of 1 to 5 is about natural size. Based on A. F. W. Schimper, 'Die indo-malayische Strandflora', *Botanische Mitteilungen aus den Tropen*, Heft III, Tafel 7 (Jena, 1891).

repertory of species which extend with monotonous regularity over the whole Pacific. Though most of the coral island plants are very widely distributed, there are a few exceptions; for instance in Laysan, a coral island of the Hawaiian group, there is an endemic species of sandalwood. As with coastal vegetation in general, the explanation of the wide distribution of the coral island flora lies in its means of dispersal; nearly all the flowering plants have seeds or fruits which are either adapted to distribution by ocean currents or else are dispersed by birds. The few ferns and other lower plants reproduce by microscopic spores which are light and easily carried by the wind.

Even in the smallest islands the vegetation is not uniform, as slight differences of height, slope and soil produce a number of distinct habitats for plants, each of which has a slightly different assemblage of species. (Profiles showing types of vegetation for Jarvis and Sydney islands will be found in vol. II, p. 454.) The vegetation of the beach is on the whole like the strand vegetation already described, consisting of low-growing, salt-tolerant plants such as the goat's-foot convolvulus. The beach flora of the coral islands is however poorer than that of the 'high' islands and there are perhaps fewer plants of trailing growth. On many of the smaller and drier islands similar vegetation extends over the greater part of the area, most of the surface being occupied by scattered clumps of herbaceous plants such as *Sesuvium*, *Heliotropium anomalum*, *Portulaca* and *Boerhaavia*. The bunch grass *Lepturus repens* is very common, either by itself or mixed with the plants just mentioned; it is particularly characteristic of the beach crest and other open unprotected places (Plate 33).

In most coral islands at least a part of the interior is occupied by bushes, growing either scattered or as a thick scrub a yard or more high. The commonest species are *Scaevola frutescens*, *Sida fallax* and *Suriana maritima*. In some of the leeward Hawaiian islands the endemic *Chenopodium sandwicheum* plays an important part.

On the wetter islands forest covers most of the area and on many of the drier ones there are open woodlands or at least clumps of trees. The coconut is of course by far the commonest and most important tree. It is planted on every available acre of dry land, and even shingle banks and tiny islets with no other plants but a few lichens often have their few stunted and battered palms. Usually coconuts grow in plantations which are clearly of recent origin, but on

some islands there are forests of coconuts which look natural. Though the palms seed themselves, there is little doubt that these forests have all originated from trees planted by early Polynesian colonists. Other trees which form woods on coral islands are the tree heliotrope (*Tournefortia argentea*), which has a preference for the dry beach crest, and *Pisonia grandis*, which on some islands forms forests of considerable height and extent. Trees found in smaller numbers include the common beach-forest species such as *Calophyllum* and *Barringtonia*, also *Guettarda speciosa*, *Thespesia*, and *Cordia subcordata*; *Pandanus* species are common either in groups or scattered among other trees.

In some islands there is a damp central depression in which marsh plants such as the shrub *Jussieua erecta* are found. Washington island seems to be unique among coral islands in having two peat bogs covered with reeds, *Pandanus tectorius*, and the taro-like *Cytosperma chamissonis* as well as a freshwater lake in its low-lying interior. In the atolls of the Western Pacific poorly developed growths of mangroves (mainly *Rhizophora*) often fringe the central lagoon.

Under perfectly natural conditions it would be expected by analogy with other parts of the world that the vegetation of a coral island would undergo a natural development or plant succession. The island would first of all be colonized by a small number of low-growing and very hardy species, which would later give place to taller and more exacting species able to grow only with the help of the shelter and humus provided by the pioneer species. On islands with a climate damp enough for trees the succession would then lead to the establishment of forest; where the climate is drier the final stage would be some form of scrub. It is thus likely that the open vegetation of herbaceous plants and grasses, the scrub of bushes, and the woods of *Tournefortia*, *Pisonia*, etc., in this order, do in fact represent stages in a succession. But the course of development has been very much altered by human interference. Coconut palms and other trees have been planted and the demand for timber and firewood has checked the development of natural forests, or destroyed those already existing. On many islands phosphate digging has destroyed the vegetation over large areas; when the diggings are abandoned plants soon begin to colonize the bare ground and a new succession begins. On Nauru the fig *Ficus prolixa* has been noted as an early colonizer of worked-out phosphate lands.

Vegetation of 'High' Islands

The types of vegetation to be considered under this heading are so many and vary so greatly from island to island that it will be possible to survey them only briefly. For the purposes of description a rough division may be made into vegetation of wet and dry climates and into primary and secondary types.

It has just been pointed out that the vegetation of coral islands tends to undergo a natural development or plant succession; the same is of course true of all other vegetation. Plant successions consist of a series of unstable stages, each one preparing the way for the next, till a final relatively stable stage is reached called the climatic climax, because the climate sets a limit to further development. Throughout the Pacific area, except for a few small regions where the conditions seem to be too dry for any sort of tree growth, the climax vegetation is evergreen forest. Where the climate is dry or semi-dry, the climax will be dry evergreen forest, scrub savannah or grassland. Occasionally the soil may be so porous or otherwise unfavourable for plant growth that succession is permanently checked at a stage earlier than the climatic climax; under these conditions the vegetation reaches an edaphic or soil climax. An example in the Pacific of what is probably an edaphic climax is the scrub on the serpentine soils of New Caledonia; the climate here would probably allow trees to grow, but the porous and sterile soil prevents it.

Stages in both kinds of succession can be seen on every Pacific island. Particularly good examples of primary successions can be seen on the lava flows of Hawaii. Great rivers of lava have flowed down from the volcanoes, cooled and solidified. In the course of years the lava has weathered and soil has formed on it. Plants have begun to grow, first in the cracks, later on the surface as well. The first plant colonists have helped on the process of soil formation by the action of their roots and by contributing humus, and so brought about improved conditions for their successors. The first plants on these lava flows are algae, mosses and lichens, which require little soil; later come ferns, bushes and small trees, among which *Metrosideros polymorpha* is one of the most important. Finally a tall forest is established. The time taken by this succession and the exact sequence of stages depend, among other things, on the nature of the lava; on the smooth *pahoehoe* lava, plants arrive sooner and the succession proceeds faster than on the *aa* lava, which consists of piles of separate blocks. A very similar primary succession can be seen on

Savai'i in Samoa, where there are also lava flows of different ages; flows 100–150 years old already have trees growing in the cracks or on soil on the surface.

Secondary successions take place when the original vegetation (whether climax or not) has been, for instance, felled, burnt or grazed; almost always they are due to man or to his domestic animals. Since human influence is profound on almost all the Pacific islands, a very large number of the types of vegetation, including some that at first sight seem entirely 'natural', are in fact stages in secondary successions. Secondary, like primary, successions, tend sooner or later towards the re-establishment of the climatic climax. Very often, however, the interference by man or animals continues, and an apparently stable type of vegetation, a biotic climax, results. Most, perhaps all, grassland of the Pacific, except that above the climatic tree limit in the high mountains of New Guinea, and some which may represent stages in primary successions, is probably a biotic climax. It probably occupies the site of former forest and would revert if protected from grazing and fire. (Types of grassland are shown on Plates 39, 42, 45.)

Without careful investigation it is often impossible to say whether a given type of vegetation represents a climatic or a biotic climax. It is nevertheless essential to bear in mind the difference between primary types of vegetation which, when they reach the climatic climax, are for practical purposes stable and unchanging, and the secondary types which depend on the activities of man and domestic animals. These are unstable; they can, and frequently do, change rapidly and completely. This is particularly true of regions like the Hawaiian islands where the great influx of population since European colonization began has had disastrous effects on the native vegetation.

Primary Types in Wet Climates (Rain Forests)

Rain forest covers, or did cover at one time, all the land area in the Pacific except some of the coral islands, the tops of the highest mountains in New Guinea and the Hawaiian islands, the dry lee sides of certain islands, and certain other dry areas such as Easter island, parts of New Guinea, and most of New Caledonia. These rain forests, though they are all evergreen and have a superficial similarity, are very varied in character, and knowledge of them is still so incomplete that a satisfactory classification is not yet possible. A rough division can however be made into (*a*) tropical rain forests,

which are tall and luxuriant and composed of a very large number of species of trees, and (*b*) subtropical and montane rain forests, which are less tall and luxuriant and considerably less rich in species. Tropical rain forest occurs in the tropical lowlands where the mean temperature is about 77–79° F., with little seasonal variation. Subtropical and montane rain forest occurs outside the tropics or on mountains within them, and has a lower mean temperature which may show a range of several degrees between summer and winter.

Tropical Rain Forests

These reach their highest development in the Pacific in the lowlands of New Guinea and the neighbouring islands, especially New Britain (Plate 35), the Solomons (Plate 34) and the New Hebrides. Essentially similar forests occur in Samoa (vol. II, Plate 114, p. 587), and on the windward side of the larger Fiji islands. Before the destruction of the original vegetation by man, tropical rain forest doubtless existed at low altitudes in the Society islands, Marquesas, Hawaiian and other 'high' islands, but at the present day what forest is left at low altitudes seems to be secondary.

Tropical rain forest corresponds with the popular idea of a tropical forest and that on the Pacific islands is similar in its general features to the vast rain forests of the Malay archipelago, equatorial Africa and tropical America. It is often described as impenetrable, but as a matter of fact in virgin as opposed to secondary rain forest, the undergrowth is rarely very dense. Except for thick patches where a tree has fallen down, it is possible to move about with little difficulty, though a man is seldom visible at a greater distance than perhaps 20 yd. It is usual to 'cut a path' with a large knife when traversing the forest; this is as much in order to retrace one's steps if necessary as for any other reason. Where there is any kind of break in the forest (for instance where a road or wide river crosses it), the undergrowth does in fact become very dense. The edge of a forest along a clearing, road or river appears as a solid wall of vegetation, but it gives a misleading idea of the forest interior. The air in the forest is extraordinary still, but though the forest is gloomy, the forest floor is dappled with sunflecks. The contrast between light and dark patches is so sharp that it is impossible to take good photographs except when the sun is behind clouds.

Tropical rain forests are not a mass of brilliant and varied coloured flowers. Plants with showy flowers do exist, but they are not common and need looking for. The majority of trees have very

small greenish or whitish flowers, inconspicuous even to the eye of the botanist. The forest as a whole is a sombre green.

The crowns of the trees in a tropical rain forest are arranged in about three superposed layers or storeys, somewhat like the oaks and hazels in an English coppice, though from ground level this is by no means obvious. The topmost storey consists of trees about 100–150 ft. high or perhaps less; the second storey is at about 50–80 ft., and the third at about 25 ft.; below this again are shrubs, saplings and a layer of herbaceous plants, generally thinly scattered, not massed like the primroses and bluebells in an English wood. A unique type of rain forest is found in New Britain. Here the topmost storey is formed by *Eucalyptus deglupta*, a superb straight-trunked tree reaching a height of over 230 ft. The crowns of the *Eucalyptus* are raised far above the second storey and are not visible from the ground.

In all the storeys the trees are mostly evergreen in the sense that their leaves are not dropped all at once, or if they are, the new leaves expand before the old have all gone. Some of the taller trees, however, may be deciduous and are bare for a few days or weeks. They differ from the deciduous trees of colder climates in being less synchronized in their behaviour; where several individuals of the same species are growing side by side, one may be fully green, another bare, another just producing a crop of fresh young leaves. A characteristic feature of rain forest trees is that the young leaves are often brilliant red or purple, and occasionally dead-white like paper; often when they expand they hang down limply as if wilted.

The trees of the top storey have tall straight trunks, thin in proportion to their length; trunks over 3 ft. in diameter are rare. The crown is often rather flattened and when seen in an isolated tree seems disproportionately small. The leaves are commonly oval, undivided and leathery, of about the size, shape and consistency of a laurel leaf.

A striking feature of many of the taller trees (in the first and second storeys) is the plank buttresses which support the base of the trunk. These are thin plate-like outgrowths extending up the trunk sometimes for as much as 20 ft., and outwards along the ground for about the same distance. They add greatly to the labour of felling the trees because a platform has to be built so that the axeman can cut the trunk above them.

The second and third storey trees have much smaller and narrower crowns than those of the first storey; their trunks are of course still

more slender. The average size of their leaves is greater and they are often drawn out into characteristic long fine points at the tips.

Both palms and tree ferns are found in the rain forest but neither are usually very plentiful, though small palms sometimes form a large part of the undergrowth. Tree ferns are usually restricted to fairly high altitudes, and to moist sheltered places, such as ravines.

Besides the trees, shrubs and low-growing herbs, the rain forest includes two groups of plants, both highly characteristic of it, the lianas or woody creepers, and the epiphytes. The lianas, like the ivy, use the trees merely as a support and do not take nourishment from them. They spread from tree to tree, often hanging down in huge loops or festoons and their stems may reach a length of several hundred feet. The leaves and flowers of these lianas are mostly far out of sight among the tree tops. Their stems vary in thickness from that of a little finger to that of a thigh; some are round in section, others are flattened like a gigantic ribbon, others twisted and closely resembling a stout rope or cable. In the rain forests of New Guinea rattans are common; these are climbing palms, often with thorny stems, which because of their great length and strength can be used for innumerable purposes in place of rope or wire.

The epiphytes include many orchids with strange and beautiful flowers and a large variety of ferns. They grow perched up on the trees and like the lianas most of them are not parasites. The only soil available for their roots is the dead leaves which become entangled with them or are brought by ants. Perhaps the most remarkable of the epiphytes are the 'strangling' figs, belonging to the same genus as the edible fig and the banyans. They start life as epiphytes, but soon strike down roots into the ground. In course of time the tree which supports them becomes surrounded by a network of tough roots, eventually it dies and the fig is left as an independent tree, its 'trunk' consisting of a hollow cylindrical network of roots. The life-history of *Metrosideros*, a common tree of montane rain forest in the Pacific, is similar.

By far the most important characteristic of the tropical rain forest, and the one in which it differs most from temperate woodlands, is the enormous number of species of trees composing it. In an English wood the great majority of the trees are, say, oaks, with perhaps a few birches, ashes or other trees intermingled. In a Pacific rain forest on the other hand, as a rule no one species of tree is dominant; there is a mixture of a vast number of different kinds of trees, no

Plate 37. Coniferous forest, Arfak mountains, Dutch New Guinea
The altitude is about 6,700 ft.

Plate 38. Mountain forest, Anggi-Gita, Arfak mountains
The altitude is about 4,500 ft. The trees are mainly species of *Araucaria*.

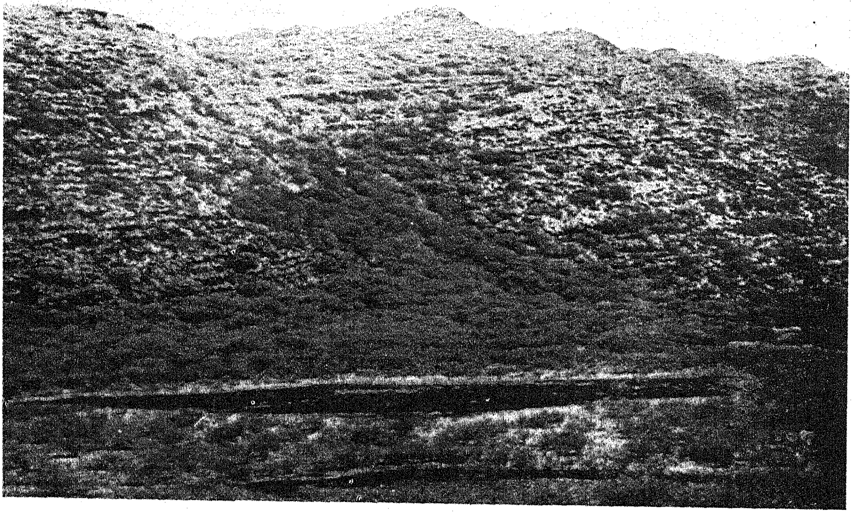

Plate 39. Vegetation of the dry zone, Oahu
From the summit of Kalama crater looking across the Kalama valley. The valley floor is covered with *Prosopis chilensis* ; the lighter coloured vegetation is grassland of *Heteropogon contortus*. The ridge in the background is 1,000 ft. high.

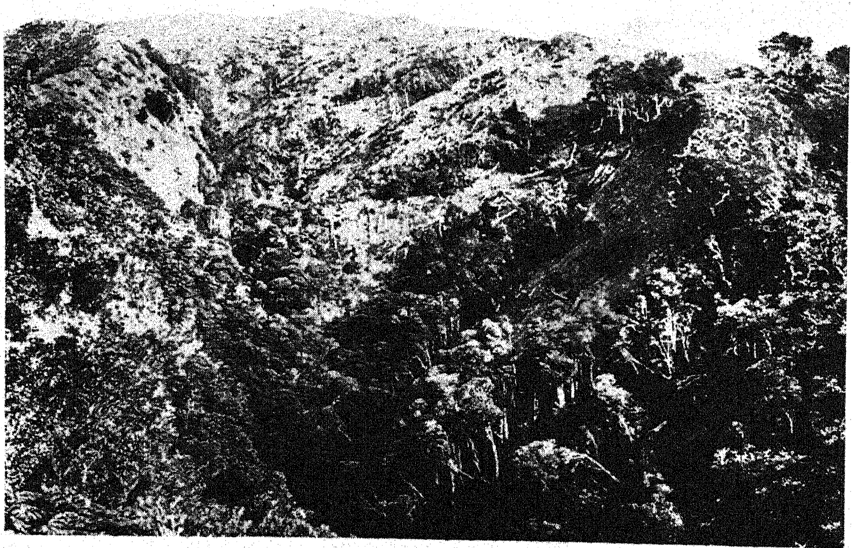

Plate 40. Sub-tropical rain forest, Más-afuera, Juan Fernández
The chief tree is *Murceugenia Schultzei*.

one of which forms a large fraction of the whole number. In the Veimauri forest in Papua, for instance, there were 437 trees of over 5 ft. girth on a 108 acre sample plot; these belonged to 69 species, of which no one formed more than 10% of the total. One may often see only a single tree of a particular species during a whole day's march. The species in each storey are different, though of course those of the lower storey include many young individuals of species which reach the high storeys when fully grown. Though rain forest is normally a fairly even mixture of species, exceptionally a single species may be dominant over a considerable area. Thus along large rivers in New Guinea the magnificent *ilimo* or *erima* (*Octomeles sumatraensis*), may form an almost pure growth. Trees of the family Dipterocarpaceae, which forms a large proportion of the bigger trees in the forests of the Indo–Malayan region, are found in the Pacific only in New Guinea and even there are not particularly abundant.

The hundreds of species of trees forming the rain forests of New Guinea, Fiji, and Samoa include many which furnish valuable timbers and other useful or potentially useful products, such as gums and resins. The great majority, however, have at present no important uses though doubtless future research may discover some. Since the valuable species are found scattered through a mass of more or less useless species, the mixed composition of rain forests is a serious economic disadvantage. The majority of the large trees in virgin rain forests are hardwoods, often excessively hard and so heavy that they will scarcely float in water. Good timbers for constructional work are common and there are also many beautiful ornamental woods, but there are few soft woods which will serve the purpose of deal.

A number of rain-forest trees are poisonous; there is *Antiaris*, for instance, said to be the original of the fabled Upas Tree. The unpleasant nettle tree, *Laportea*, recognizable by its red-veined, stinging leaves, is found in rain forests in the New Hebrides, New Guinea and elsewhere.

Similar in many respects to the tropical rain forests are the *fresh-water swamp forests* which cover a vast area in the low-lying river valleys of New Guinea and New Caledonia, and are doubtless found on a smaller scale in the neighbouring islands. These swamp forests, which are an edaphic climax in which the succession to normal rain forest is prevented by the waterlogging of the soil, are of more than one kind; most are mixtures of broad-leaved evergreen trees, with

or without palms. As a rule, owing to the softness of the ground and the number of lianas and plants with stilt roots, they are extremely laborious to traverse. The most important and perhaps the most widespread type of swamp forest in New Guinea is the sago forest, dominated by palms of the genus *Metroxylon*. These palms provide the staple food for many of the native tribes.

Subtropical and Montane Rain Forests. These differ little from each other, and they differ in degree rather than in kind from tropical rain forest. Subtropical rain forest (Plate 40) is seen on Lord Howe island, the Kermadecs, Juan Fernández (though the forest here should perhaps be termed temperate rather than subtropical) and possibly in a few more islands south of the actual tropics. Montane rain forests (Plate 38) cover the higher ground of most of the 'high' islands, often coinciding fairly exactly with the 'mist zone' which is covered with an almost permanent cloud cap.

Both these kinds of forests are less tall, less luxuriant and composed of far fewer species of trees than the tropical rain forest. They often lack features characteristic of tropical rain forest (for instance the trees generally lack plank buttresses), rather than having characteristic features of their own.

The trees are usually only 60 to 80 ft. tall, often considerably less; rarely they may reach 100 ft. Generally there are only one or two storeys of trees in addition to shrubs and herbs. The trunks are less straight than in tropical rain forest, and thicker in proportion to their length. The crowns of the larger trees tend to be spreading, with a tendency to be umbrella-shaped. An important difference from tropical rain forest is that the average size of the leaves is much smaller; speaking very generally they tend to resemble those of a holm oak rather than those of a laurel. In New Guinea, where a series of zones of forest follow one another from the lowland tropical rain forest to the tree limit at about 14,000 ft., a gradual diminution in the average leaf size with increasing altitude can be noticed.

The number of species of trees, though always less than in tropical rain forest, varies within wide limits. In the subtropical (or temperate) rain forest of Juan Fernández the tree storey proper consists of only three to six species, but in montane rain forest between 6,000 and 9,000 ft. in New Guinea a sample plot of 40 acres had 229 trees of timber size belonging to 24 species. Like the species, the number of families of trees is restricted. Some characteristically tropical families are absent and temperate families appear in their places. The two families most constantly and abundantly present are

probably the Myrtaceae (Myrtle family) and the Araliaceae (Ivy family); both of these however are present, though less conspicuous, in the tropical rain forest. The presence of conifers (Fig. 58; Plate 37) such as *Araucaria* and *Podocarpus* is generally characteristic of montane rain forest in the Pacific; in tropical rain forest conifers are usually absent altogether. The kauri pine (*Agathis*), in the tropical forests of Fiji and Vanikoro is an exception. The abundance of these conifers is variable: in the Hawaiian islands they are absent, but in New Guinea they are plentiful and in the higher mountain forests above about 10,000 ft. become the dominant trees.

Palms and tree ferns are often a conspicuous feature of subtropical and montane rain forests and, though never dominant, may be very abundant, sometimes standing out above the level of the other trees. Lianas are usually much scarcer than in tropical forests, though here again there is much variation. In Juan Fernândez there is only one species of liana, which is probably introduced. Epiphytic flowering plants are generally few in species and may be absent altogether, but epiphytic mosses, liverworts and lichens are nearly always plentiful and are sometimes a conspicuous feature.

It is clear that the types of forest here grouped together as montane and subtropical rain forests are very heterogeneous. Though we do not yet know enough about them to distinguish the different kinds, one or two distinct types stand out from the rest, for example the mossy forest found in the mist zone of islands such as the Marquesas and on the mountains of New Guinea above about 7,500 ft. The trees are only about 20 ft. high and are grotesquely gnarled and twisted. The dripping wet covering of mosses, liverworts and ferns on trunks and branches gives them a fantastically swollen appearance, often making them look twice their real thickness. The soddenness of the vegetation combined with the driving mist and perpetual drizzle make the mossy rain forest a cheerless place. The dense undergrowth and network of aerial roots make it as hard as any type of forest to traverse.

As the mountains are ascended the forest changes in character, becoming, generally speaking, more dwarfed, less luxuriant and less like the tropical rain forest as one goes upwards. The nature of the forest at a given place depends as much on exposure and slope as on actual altitude; thus on exposed ridges and summits on the smaller 'high' islands the rain forest may be reduced to a mere scrub, though the altitude is only some 3,000 ft. Mist forest

similar to that occurring at about 8,000 to 10,000 ft. in New Guinea covers ridges in New Caledonia and the Marquesas which are less than 5,000 ft. high.

In New Guinea and Hawaii the mountains are high enough for the climatic tree limit to be reached and here a series of forest zones from the lowlands upwards can clearly be distinguished. In New Guinea the tropical rain forest is succeeded at about 1,000 ft. by the 'foothills forest', which is less luxuriant and also differs in having fewer lianas, epiphytes and trees with plank buttresses. In the upper part of the 'foothills forest' the first conifers appear. Between 4,500 and 7,500 ft. the foothills forest gives place to the mid-mountain forest', in which the hoop pine (*Araucaria Cunninghamii*) is one of the commonest large trees. Other conifers and two kinds of oak are also plentiful. This is a typical montane rain forest. The next zone, beginning at an average height of 7,500 ft., is the mossy forest, which has already been described. Finally, from about 10,000 ft. to the tree limit at about 14,000 ft. is a drier type of forest

Fig. 60. *Aleurites moluccana*, candlenut tree

A common Pacific islands tree. The leaves have a characteristic frosted appearance. Drawn from E. J. H. Corner, *Wayside Trees of Malaya*, vol. II, plate 55 (Singapore, 1940).

consisting predominantly of conifers (*Podocarpus*, *Libocedrus*, *Dacrydium*, *Phyllocladus*) with some broad-leaved trees intermingled. This zonation depends on the gradual change of climate: with increasing altitude temperature diminishes steadily, but humidity increases up to a maximum in the mossy forest (mist zone) and afterwards decreases.

On the windward (wet) sides of the larger Hawaiian islands three forest zones can be recognized, but the zonation is much complicated by local differences of humidity, slope and terrain (young and old lava, etc.) as well as by the partial replacement of the primary forest by secondary vegetation, so that it is difficult to give exact height limits. All three zones are mixtures of broad-leaved trees without conifers; in the lower zone characteristic trees are the candlenut (*Aleurites moluccana*; Fig. 60), and the *koa* (*Acacia koa*). In the middle zone the *ohia* (*Metrosideros polymorpha*) is characteristic, though it is present all the way from sea-level to 9,000 ft. In the upper zone the species are few and the forest has the general character of mossy forest.

The timbers of the subtropical and montane rain forests are mostly hardwoods, except for those of the conifers, and are like those of the tropical rain forest. The montane rain forests of the Hawaiian islands produce some excellent woods which are exploited on a considerable scale both for local use and export. In the other groups of islands, though there has been much destruction of the forests, the timber has not been made use of on a large scale, mainly owing to the inaccessibility of the forests. Far more important than their possible value as producers of timber is the value of these montane forests as a protection against soil erosion and in conserving and regulating the water supply of the lower, more thickly populated land. This is particularly true in the Hawaiian islands where rain forests often cover slopes which appear to be almost vertical.

Secondary Vegetation of Wet Climates (Secondary Rain Forests, Scrub, Fernbrakes, Grassland)

The types of vegetation which may arise after the destruction of rain forest are many and varied and cannot be described here in detail. In the first place there are the secondary rain forests, which differ from the virgin forest they replace in being lower and generally thicker, and more difficult to penetrate owing to the dense undergrowth and more abundant creepers. The trees are mostly soft-

wooded, rapidly-growing species which are almost worthless economically. The flora of these secondary forests is always poorer in species than that of the original primary forest. When young, secondary forest is easily recognizable, but left to itself it becomes more and more like primary rain forest. Much of the existing rain forest on the 'high' islands of the Pacific is probably secondary—for instance the 'intermediate forest' of the Marquesas, dominated by *Hibiscus tiliaceus*, and all the forest on Rarotonga, except at high altitudes.

Besides the secondary rain forest there are many other types of secondary vegetation which are much less like the original primary forest—for example the scrub formed by shrubs such as the guava (*Psidium guajava*) and the troublesome *Lantana* (Fig. 61), which cover huge areas in both Fiji and Hawaii. Another secondary type is the fernbrake of *Gleichenia* (*Dicranopteris*) *linearis* (Plate 41), a plant which perhaps covers a greater area in the Pacific islands than any other single species. It forms dense thickets 10 to 12 ft. high, which can be penetrated only by hacking a path. In many places it is spreading at an alarming rate; in Kipapa gulch on Oahu (Hawaiian islands), for instance, it is said to be advancing some 3 ft. a year. Finally there are several types of grassland which can arise after the destruction of rain forest. In New Guinea and the neighbouring islands there are large areas of the tussocky *alang-alang* grass (*Imperata*, Plate 46), which also covers much former forest land in the Malayan region. In the Marquesas the introduced grass *Paspalum conjugatum* is tending to replace both the primary rain forest and the 'intermediate forest'. In the Hawaiian islands a number of non-native grasses have established themselves over large areas.

All these secondary types of vegetation are believed to be stages in succession following the destruction of rain forest. The course of these successions may be complicated and will depend, among other things, on the kind and duration of human interference. On islands where the old forest has been entirely destroyed the succession might take a very long time and the forest might never become identical with the original owing to the lack of parent trees to provide suitable seedlings.

A general picture of the origin of secondary vegetation from rain forest can be obtained in New Guinea, where the course of events seems to be fairly straightforward. The natives, as in most tropical countries, practise shifting cultivation. A patch of virgin tropical rain forest is cleared by felling and burning, and one or two crops

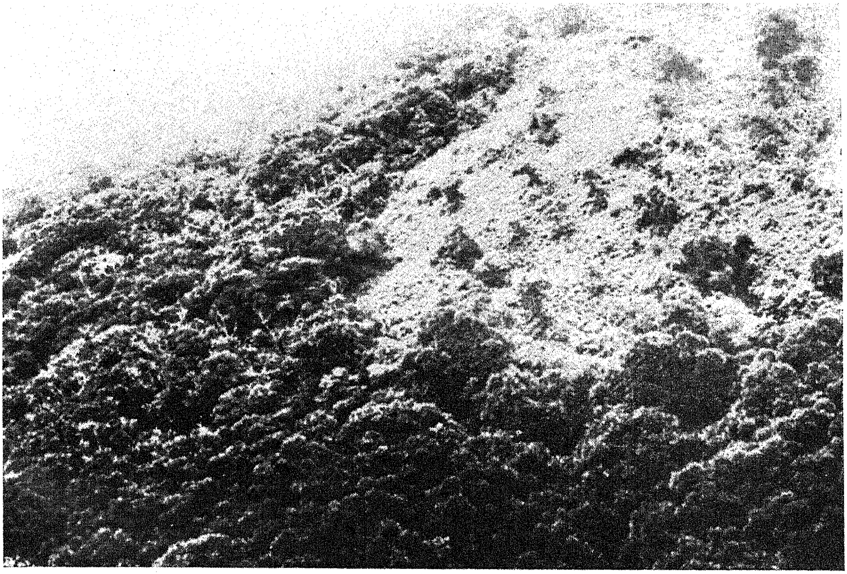

Plate 41. Secondary vegetation, Kuliouou gulch, Oahu

The area is in the zone of *Acacia koa*. Secondary forest of *Psidium cattleianum* var. *lucidum* (a species of guava); light patch, a fern brake of *Gleichenia linearis* with remains of the original tree-cover.

Plate 42. Secondary grassland, upper Ramu basin, New Guinea

This grassland probably replaces former forest; trees

Plate 43. Scrub vegetation, Galápagos islands
Dry season conditions on the limestone plateau near Wreck bay, San Cristobal.

Plate 44. Scrub with cacti, Galápagos islands
Vegetation of the volcanic soils of Chatham island.

of taro (Fig. 62), yams or sweet potatoes (Fig. 68) are grown. The land is then abandoned and in an incredibly short space of time small soft-wooded trees such as *Trema*, *Alphitonia* and various species of *Macaranga* spring up and soon form a dense secondary forest 20 to 60 ft. high. These trees are short-lived and in course of time they are replaced by slower-growing species which have grown up in their shelter. These slow-growing trees are similar to those found in the virgin forest and, after a period, the length of which is unknown, the succession, if undisturbed, would undoubtedly lead back to something very like the original rain forest. The natives however often clear the land again after a lapse of about 8 to 10 years, which gives time for the humus used up in the last brief period of cultivation to be built up again in the soil. Civilized government and peaceful conditions tempt the natives to cultivate the land on a shorter cycle and under these circumstances grasses such as the *alang-alang* tend to invade the area and gradually convert it into useless grassland. The natives cannot cultivate the grassland; they burn it periodically to drive pigs and wallabies when hunting. In this way grassland arises as a biotic climax derived from rain forest. Destruction of forest in ways similar to this has taken place on practically every Pacific island.

Primary and Secondary Vegetation of Dry Climates

In New Caledonia, the dry belts of New Guinea, and on the dry lee side of the 'high' islands, uncultivated land is covered by evergreen forest, scrub or by some kind of grassland or savannah (Plates, 39, 45). The dry types of vegetation are naturally more liable to damage by fire and grazing animals than is rain forest and its derivatives, and probably revert to their original condition more slowly. The difficulty of distinguishing between primary and secondary vegetation is therefore greater than in wet climates, and since our knowledge of the vegetation of dry areas is very incomplete, all that can be done now is to mention some of the chief types of vegetation, leaving their classification to the future.

Dry Evergreen Forest. This is well developed in southern New Guinea and New Caledonia. On the lee sides of the Hawaiian islands a dry type of forest is found above about 1,000 ft., but at lower altitudes the native vegetation of the dry regions has been almost completely replaced by weeds and cultivation. Relics of dry evergreen forest exist in Fiji and the Marquesas; in Easter island, which today is covered with an almost treeless grassland, a

careful study of the vegetation and climate suggests that at the time the island was first colonized by the Polynesians it may have been covered with a forest of the small tree *Sophora toromiro* and perhaps by other endemic trees which are now quite extinct. Many dry areas which are now covered with grassland—e.g., much of the south-east coast of the Gulf of Papua, and the *talasinga* country (i.e., leeward land with a low rainfall) of Fiji—were quite probably forested at one time, but most of the trees have long since disappeared, owing to felling, persistent burning and grazing.

The most typical dry or savannah forests of the Pacific are probably those of New Guinea. The chief trees are species of *Eucalyptus* associated with other Australian trees, such as the paper-bark (*Melaleuca leucadendron*) remarkable for its silvery leaves and thick fissured bark, which peels in thin papery strips. In the foothills, groves of a species of *Casuarina* appear. The whole appearance of these forests is almost exactly like those of the drier parts of Queensland.

A remarkable series of types of dry forest, varying very much in character, is found in New Caledonia. On the one hand there are close evergreen forests with a shade-bearing undergrowth, the trees reaching a height of about 100 ft.; on the other there are open savannah woodlands of *Melaleuca* (here called *niaouli*) with a ground cover of grasses and herbaceous plants. The tall closed forests differ only slightly from rain forests; the trees tend to have rather smaller and more leathery leaves. Lianas, as in the rain forests, are a characteristic feature, but epiphytes and other plants of damp climates are scarce or absent. These dry forests are extremely rich in species, the great majority of which are endemics not found outside the island. A peculiarity of New Caledonia is that though conditions of soil and climate seem much like those of Australia, of the two genera of trees most typical of Australia, the gums (*Eucalyptus*) and wattles (*Acacia*), one has no native species and the other only two in the island.

The native dry forests of the Hawaiian islands have been little described, but it appears that they are of mixed composition and very rich in species, considerably richer than the Hawaiian rain forests. Though the conditions are such that many of the trees would be expected to lose their leaves in the dry season. only three or four species are deciduous, the great majority being evergreen. Lianas are few and the undergrowth is surprisingly scanty. At latitudes up to 2,000 ft. large areas are covered with secondary

Plate 45. Grassland in western Nukuhiva, Marquesas
The chief grass is *Rhaphis aciculata* ; note the trees along the watercourse.

Plate 46. Secondary grassland, Buka, Solomon islands

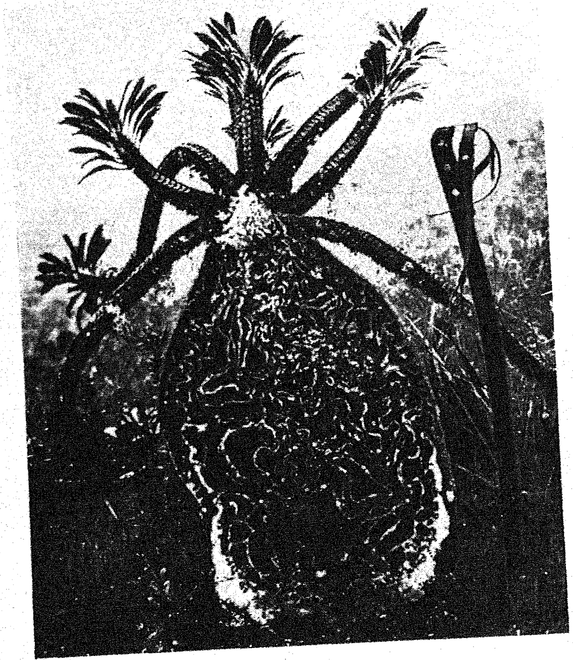

Plate 47. *Myrmecodia*

The plant has been cut longitudinally to show the cavities inhabited by ants.

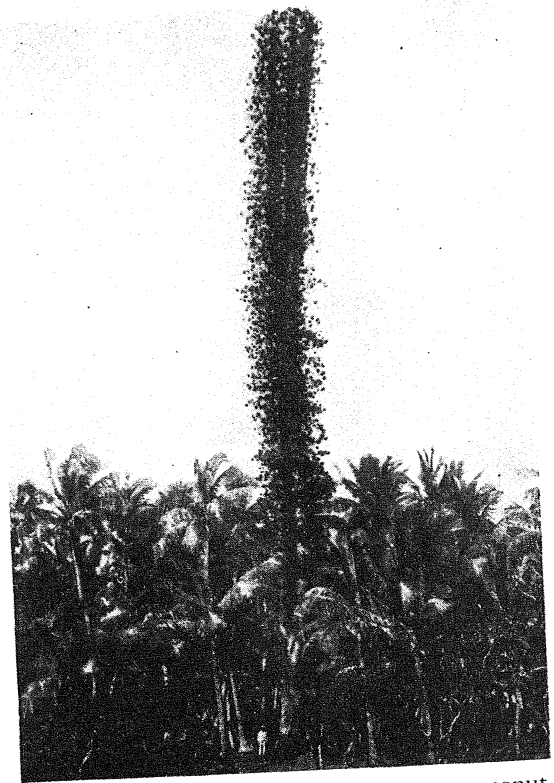

Plate 48. *Araucaria columnaris*, among coconut palms, Yaté, New Caledonia

The Isle of Pines owes its name to this extraordinary conifer. When the botanist Forster saw these tre , (on Cook's second voyage), he mistook them fo. basalt columns.

woodlands of the *algaroba* or *mesquite* (*Prosopis juliflora*), a tree introduced into the island over a hundred years ago and now spreading spontaneously. Some of these woodlands occupy what were once barren dusty plains on which all natural vegetation had been destroyed. The tree supplies food and shelter for cattle, and firewood, and is a valuable protection to the soil against erosion; the *algaroba* woodlands are therefore an exception to the rule that secondary forests are generally of little economic value.

Though extensive thickets of the introduced guava and *Lantana* are a feature of many dry areas in the Pacific, indigenous *scrub* is not widely developed. On the serpentine areas of New Caledonia there is a very interesting scrub, which as already pointed out, is probably an edaphic climax depending on the peculiar soil conditions. It consists of bushes growing scattered or in clumps, with bare ground between. The number of species is enormous; almost every bush seems to be different from all the others. A characteristic of many of them is that the leaves are either hairy or else extremely shiny, sometimes looking like polished metal. Almost all the species in this scrub are endemic and many are of great botanical interest, but except to the botanist the scrub is a useless wilderness.

Scrub of a very different kind is the characteristic vegetation of the Galápagos islands (Plates 43, 44), except at high altitudes where the damper climate allows the growth of montane rain forest. This scrub consists largely of cacti and other thorny plants. Though many of the species are endemic, the general appearance is much like that of thorn scrub in semi-arid districts of South America.

Dry open woodland such as the *Melaleuca* savannah woodland of New Caledonia grades insensibly into *savannah*, and savannah into treeless grassland. Typical savannah, consisting of open grassland with clumps of trees and bushes, covers large areas in southern New Guinea. The *talasinga* country of Fiji, in which the ground is mainly covered with the tall reed-like grass *Miscanthus japonicus* (or possibly *M. floridulus*) is very similar. Savannah also exists in the dry parts of the Marquesas and in Tonga. In Yap (Carolines) there is a savannah consisting of a mixture of grasses and many herbaceous plants with great numbers of unevenly scattered pandanus trees. In savannah areas the rivers and streams are generally marked by a line of trees or belt of forest, the so-called gallery forest, the growth of which is made possible by the moisture in the soil (Plate 42).

Grasslands of native species are found in the Marquesas and in

Easter island. The grasslands of the Marquesas (Plate 45) are of considerable botanical interest as the grasses of which they are composed are endemics whose nearest relatives are believed to be American. As well as growing on areas which are kept deforested by grazing, they grow on the sea cliffs where erosion is so rapid that trees cannot establish themselves. Sheep and cattle graze on these native grasslands, but the more important cattle-raising industries of Hawaii and New Caledonia depend on artificial grasslands composed of introduced grasses.

Vegetation of High Mountain Summits

In the New Guinea mountains at a height of about 12–14,000 ft. the trees at last disappear, giving place to alpine grassland, bogs, low scrub and bare rock, with snow fields and glaciers on the very highest summits. In many places the apparent natural tree limit is due to the destruction of the forest by native hunting fires, but the true climatic tree limit seems to be reached at about 14,000 ft. On the highest Hawaiian volcanoes the tree limit is at about 8,000 to 10,000 ft., and above this there is mostly lava sparsely covered with scattered bushes and herbaceous plants. Some summits have a peculiar and interesting bog vegetation, including among other plants one of the English species of sundew (*Drosera*). Both the New Guinea and the Hawaiian high mountain flora is interesting, chiefly because of the number of species it contains which are identical with, or nearly related to, plants usually found much further north. Thus in New Guinea there are rhododendrons and gentians like those of the European Alps; in Hawaii the alpine flora includes relatives of the European buttercups, wood sanicle and wild geraniums.

HISTORY OF THE VEGETATION

No one can study the vegetation of the Pacific islands without speculating about its origin. How were these islands, some about 1,000 miles from any other land, stocked with their plant population? Where did the plants come from? What changes has the flora undergone in historic times and in the geological past? The answers to all these questions must be very incomplete and hesitating because on all of them expert opinion is far from unanimous. It is mainly in the study of plant distribution and dispersal that the

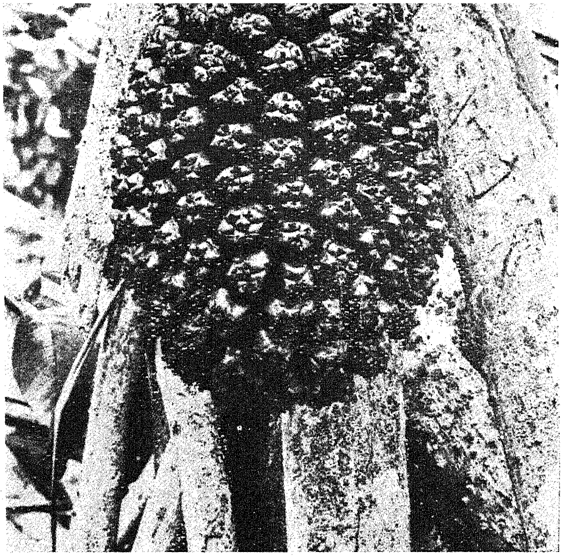

Plate 49. Fruit of *Pandanus mei*

The seeds are edible. The pulp of the fruit is fermented to make a drink and is used as food in times of famine.

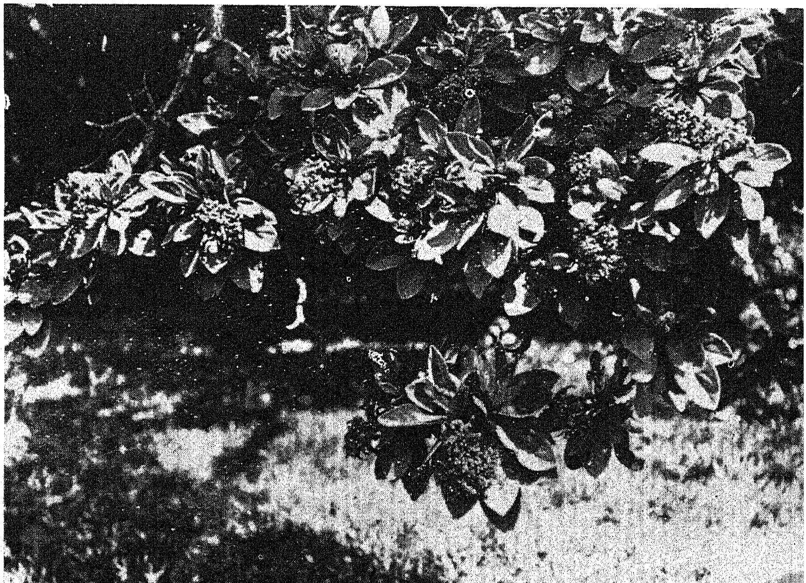

Plate 50. *Tournefortia argentea*, the tree heliotrope

This photograph is of a tree growing on the shore at Whitesands, Tana. N Hebrides.

Plate 51. The mangrove *Rhizophora mucronata*
The stilt roots are characteristic of the genus. Note the scattered mangrove seedlings in the deeper water in the background.

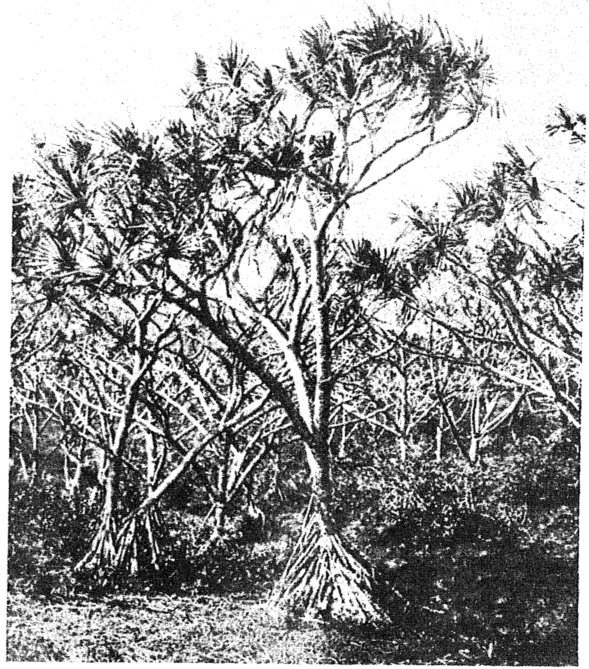

Plate 52. A forest of *Pandanus odoratissimus*
This forest is in the east of Maui, Hawaiian islands. Note the characteristic stilt roots. *P. odoratissimus* is one

answers to these problems must be sought, because up to now geological evidence has proved very disappointing. Since the problems of animal life in the Pacific are very similar to those of the plants, the distribution of animals must be studied side by side with that of the plants.

Theories of Origin

Two fundamental facts must be considered at the start. First, there is, as has already been seen, a striking difference between the flora of the coral islands on the one hand and that of the 'high' islands, including New Guinea, on the other. On the coral islands the flora consists mainly of widely distributed species, many of them found not only throughout the Pacific, but in other parts of the tropics as well. Nearly all these species have seeds or fruits which could be easily carried by birds, wind or ocean currents, and for some of them there is direct evidence that they are so carried and can establish themselves when they arrive. The coral islands are probably all, geologically speaking, very young and their flora mostly consists of recent immigrants. The 'high' islands are quite different; in addition to the wide-ranging species found on the coral islands, there are many more, a large proportion of which are endemics limited to a single island or group. New Guinea is an ancient land mass; the 'high' islands of Polynesia which are volcanic and therefore cannot be dated with any accuracy, though perhaps not very old in the geological time-scale, are certainly old compared with the coral islands.

The second fact which has to be considered is that the islands of the Pacific fall into two groups, those east and west respectively of a line running east of New Zealand, near Tonga, east of Fiji, the New Hebrides and Solomons, and north of New Guinea. West of this line the islands all rise out of comparatively shallow seas and many of them are connected with each other or with the neighbouring large land masses by submarine ridges. Those to the east, on the other hand, rise out of the great Pacific depression, an area of sea over 2,200 fathoms deep (Fig 6, p. 11), or from the Albatross plateau beyond it. As far as the islands west of the depression are concerned, there is no serious division of opinion; it seems clear that they received their present population of plants and animals either across connecting land-bridges which have now disappeared under the sea, or across fairly narrow stretches of open water. Even here there are many mysteries to clear up; how, for instance, are we to

explain the presence in Lord Howe island of *Moraea*, a genus of the iris family, the other species of which are all found in South Africa and Madagascar? Some at least of these western islands have been isolated for a very long time, as is shown by the high percentage of endemics in New Caledonia.

On the origin of the flora and fauna of the islands rising from the Pacific depression and the Albatross plateau there are, broadly speaking, two views. The one is that the depression was once occupied by large masses of land which disappeared in the late Secondary or early Tertiary Period leaving relics of its plant and animal life on the present 'high' islands. Opposed to this is the view that the 'high' islands rose up from a depression which has never contained any large land masses and that the plants and animals found on them are waifs which have been carried over the sea by winds, birds and currents—that is, by the same means as those by which plants have reached the coral islands, but operating over a much longer period.

There are strong arguments in favour of both views and both have to meet difficulties which at present seem insuperable. There is no definite geological evidence in favour of the former existence of land masses in the Pacific depression. The chief arguments for the migration of the flora and fauna by means of land connections are: firstly the difficulty of understanding how, for instance, the relatively rich flora of the Hawaiian islands could have crossed some 1,000 miles of ocean with only the means of dispersal available at the present day; and secondly the existence of an 'Old Pacific Element', a group of apparently very old species which have no near relatives on any of the continents bordering the Pacific. There are also striking resemblances between the flora of extremely distant islands, e.g., Hawaii and the Marquesas, Juan Fernández, and the Western Pacific islands. Against this must be set facts like these:—(i) the Hawaiian islands and most other islands in the depression have no large land animals, except bats, which are not certainly introduced; (ii) islands of the depression have a striking lack of heavy-seeded plants (e.g., the nutmegs, *Myristica*, which are not found east of Samoa), except those which grow on the seashore and have seeds or fruits which float; (iii) the animals and plants are nearly all species which at least theoretically might be carried by the means assumed; (iv) the fauna and flora of the islands includes many 'gaps'—that is, whole families which are present on the surrounding continents are absent for no apparent reason, the

missing families being usually the same on all the islands. At the same time there are other difficulties on the other side. Thus the *Lobelioideae* and land snails of the Hawaiian islands are often found only on one island: if their ancestors were carried over some 1,000 miles of sea, why are the present-day species apparently unable to cross only a few miles?

Whether the migration was mainly overland or mainly by sea, it is clear, as has already been stated, that the bulk of the Pacific flora originated in the Indo-Malayan region, smaller contingents coming from Australia and from South America. There is also much evidence that the continent of Antarctica, which was probably once covered with vegetation, and not with ice as now, was a source from which Polynesia, as well as Australia, New Zealand, southern South America and possibly South Africa received some of their flora.

The flora of the Pacific must be pictured as arriving in successive waves of immigration over a very long space of time. The last wave has been the cultivated plants and weeds brought by Polynesian, Asiatic, and European inhabitants. The plants thus introduced deliberately, and still more the weeds introduced accidentally, bid fair to transform the whole appearance of the vegetation over the greater part of the Pacific.

Cultivated Plants

When the Polynesians spread over the Pacific they brought with them the chief cultivated plants of their original home in south-eastern Asia, such as coconuts, yams and taro. It was their skill in transporting and cultivating these plants, as well as their seamanship, which made their long voyages and successful colonizations possible, for no important food plants except the species of pandanus (Plates 49, 55) and perhaps the breadfruit were natives of the islands to which they came. Most of these cultivated plants were brought to the islands so long ago that they have given rise to many local varieties, each food plant having a 'centre' where its varieties are mainly concentrated—e.g., taro in Hawaii, yams in Fiji, breadfruit in the Marquesas. The history of the sweet potato is much more obscure than that of the other chief food plants. The botanical evidence indicates, without any doubt, that its original home was tropical America, but it is known to have been widespread in Polynesia in the eighteenth century and the Maori of New Zealand cultivated some 25 varieties of it. It is uncertain whether it was introduced by Spanish voyagers in the sixteenth or seventeenth

centuries or whether it is the outcome of a far earlier cultural contact between America and Polynesia.

The tobacco plant, which also originated in America, was probably introduced into the Pacific area in the sixteenth and early seventeenth centuries from Amboina and the Philippines to which it had been brought by the Portuguese and Spanish.

After Cook's voyages a vast number of food, ornamental and other cultivated plants were introduced into the Pacific and are now as much part of the landscape as the much older Polynesian introductions. Many, such as the commercial varieties of the sugar cane, citrus fruits and the pineapple, are important crops, but unlike the taro, breadfruit, etc., they are grown more for export than for subsistence.

Weeds

Weeds, which are so conspicuous a feature of most Pacific islands, have been introduced both by Polynesians and by Europeans, but the great majority are European introductions of quite recent origin. In a recent census of the weeds on the leeward coasts of Fiji, it was estimated that nearly half the species had arrived since 1900. Most of these weeds have been brought in unintentionally but some, like the guava, are cultivated plants which have run wild; a few, like Koester's Curse (*Clidemia hirta*) have been christened with the name of their well-intentioned introducer. A surprisingly large number of Pacific weeds are of American origin, but there are also many which come from southern Asia.

The impression that the weeds are actively suppressing and driving out the native flora is probably largely false. Introduced plants are rarely seen in undisturbed natural vegetation, though *Crepis japonica* now grows in the depths of the rain forest in Hawaii. Even in the open vegetation on lava flows in Hawaii, where there must be plenty of room for newcomers, there are very few introduced plants. The weed flora only becomes aggressive when the native vegetation has been destroyed or damaged; thus guava and *Lantana* only invade rain forest when it has been felled or burned. They replace but do not actually suppress the native vegetation.

One reason for the extreme vigour of some of these introduced plants in the Pacific islands is the absence of their natural insect enemies, which have been left behind in their native homes. Attempts are being made to introduce these insects and thus to right the

balance of nature by 'biological control'. Thus in Fiji *Clidemia* is being successfully checked by an introduced thrips; *Agromyza lantanae*, a fly with a seed-eating larva, and *Thecla agra*, a butterfly with a flower-eating caterpillar, have been recently introduced in the hope of checking *Lantana*.

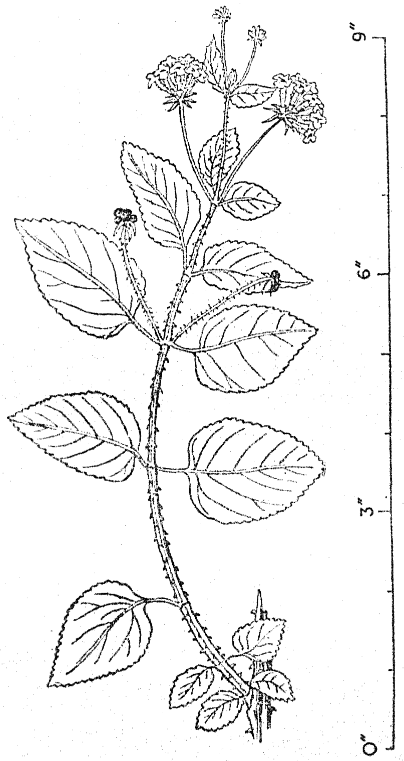

Fig. 61. *Lantana camara*

A shrub of American origin which has run wild and is now a pest in Fiji and other Pacific islands. The flowers are pink, orange or mauve. Drawn from a specimen in the Cambridge University Herbarium and from N. L. Britton, *Flora of Bermuda*, p. 314 (New York, 1918).

As a result of the destruction of the natural vegetation and its replacement by weeds a considerable number of native plants have become extinct. In Hawaii it is estimated that several hundred species have vanished since cattle were introduced. Many more are on the verge of extinction. Thus of the three species of *Hibisca-*

delphus, a handsome genus of trees known only from Hawaii, two were represented in 1913 by only a single living individual and the third by about a dozen trees.

Man and his domestic animals are not only wiping out many native species in the Pacific and converting large areas of beautiful and potentially useful natural vegetation into thickets of useless weeds, but converting valuable land into a desert. An example of a man-made desert is the *fenua ataha* or *terres désertes* in the Marquesas —land which has been deforested by goats and cattle, and now, owing to long-continued over-grazing, has very little vegetation of any kind. A similar story can be told of many other Pacific islands. For example, Laysan, one of the leeward Hawaiian islands, was covered in 1896 with good grassland and bushes 6 ft. or so high ;

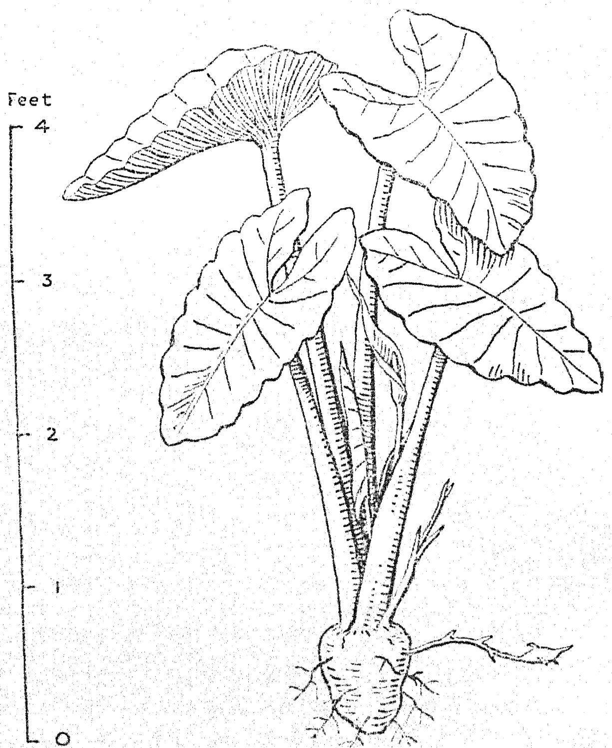

Fig. 62. *Colocasia antiquorum*, taro

The most important root vegetable of the majority of Pacific islanders. Based on *Botanical Magazine*, vol. CXX, plate 7364; vol. CXXVI, plate 7732 (London, 1894, 1900).

the flora numbered 26 species. By 1911, chiefly owing to the swarms of introduced rabbits, many of the native plants had been exterminated. In 1923 the whole island had become a waste of sand, with almost no vegetation. Only four species of plants were left and the Laysan sandalwood tree, known from nowhere else in the world, was represented by only a few dying stumps sticking out of the sand.

The history of Laysan and of many other Pacific islands shows that here, as in many other parts of the world, there is a great need for the understanding and rational exploitation of the natural vegetation.

NOTES ON SOME COMMON PLANTS

It may be useful to give here a few brief notes on some of the commonest plants to which reference has been made in this chapter and of which most of the names recur in various sections of the later volumes of the Handbook. The selection is necessarily rather arbitrary; it excludes for the most part plants found only in cultivation, but some of the species are introduced plants which have become naturalized. For convenience, the descriptions are given in alphabetical order. Some common European and native names are listed, but there are many other native names, especially in the Western Pacific, which it is difficult to extract from the literature, which are very localized, or which are still unrecorded. Some indication of the varied uses to which the native peoples put many of the plants is given, but here also the information is still far from complete.

Aleurites moluccana (Fig. 60. European name, candlenut; Hawaiian, *kukui;* Tahitian, *tutui, tiairi;* Tongan, Rarotongan, Futunan, *tuitui;* Fijian, *lauthi, tuitui, sekethi, sikethi*).

This tree, though now common throughout the Pacific, was probably originally introduced by man from the Malayan region. The nuts, which are very hard, contain an oily kernel, which is edible in small quantities. In former times, kernels threaded on a rib of coconut leaf were used as a taper or candle. The tree is tall and easily recognized by its drooping spear-shaped leaves, which are about 4 to 12 in. long and have a characteristic frosted appearance. The wood is coarse and soon decays. In Fiji, the bark is used medicinally.

Alocasia (European name, giant taro; Rarotongan and many other Polynesian dialects, *puraka;* Futunan, Tikopian, *pulaka;* Samoan, *pula'a;* Gilbert islands, *babai;* Fijian, *ndranu*).

This plant, of which two species are cultivated in the Pacific, resembles taro (*Colocasia*) but is much larger and shows a short stem above ground. It commonly grows to a height of 6 to 8 ft., and has large heart-shaped, strongly-veined, shiny leaves, and a fleshy corm a foot or so in diameter.

The leaves are used as wrappers for food, and also as umbrellas when it rains. The corm, which is hard and woody in appearance, is cooked for food; it is a staple of diet in some central equatorial islands.

Artocarpus incisa (European name, breadfruit; Tahitian name, *uru*; Tongan, Futunan, Tikopian, *mei*; Mangarevan, *tumei*; Fijian, *kulu*, *uto*; Trobriands, *kum*).

This is a cultivated tree which propagates itself mainly by shoots that spring from the roots. It grows usually to about 30 ft. but old trees may reach 40 or 50 ft. The trunk is slender, with many branches, sparingly covered with very large dark green glossy leaves up to 18 in. long; these are deeply divided into 'fingers'. There are a number of varieties of breadfruit recognized by the Polynesians, each with its own name. The fruit varies in size from that of a large orange to that of a football; it has a tough, rough rind and a soft flesh with a large core holding several seeds. The fruit is inedible when raw and if cut exudes a milky juice; when cooked it has somewhat the consistency but little of the flavour of bread. It is one of the staple foods in some Pacific islands. The leaves are much used for wrapping food, and the wood, which is red and durable, is used for a number of purposes, including house posts and canoes. An adhesive sap obtained from the tree is used as bird lime and as a caulking material for canoes. In Tahiti in former times a choice type of native cloth was made from the inner bark of some varieties of the tree. *Artocarpus integrifolia* (jackfruit), somewhat resembling breadfruit, also grows in some parts of the Pacific, but is more common in the Malayan region.

Barringtonia asiatica (=*B. speciosa*. Tahitian name, *hutu*; Tongan, Samoan, etc., *futu*; Fijian and Melanesian generally, *vutu*). This is a tree growing on sandy beaches, sometimes 60 ft. or more high, but usually shorter. The large four-sided fruits float in sea water and are one of the commonest objects of the drift on Pacific shores. The leaves (Fig. 55) are shiny and leathery and borne in rosettes at the ends of the twigs; they are 6 to 18 in. long. The flowers are about 6 in. wide, with a great tassel of pink-tipped stamens. One or two other species of *Barringtonia* grow in similar situations. The leaves are used medicinally in Fiji, and the wood, which is white, coarse and buoyant, is used in Tahiti for canoes. Generally throughout the Pacific the narcotic seeds of the fruit are used for stupefying fish to assist in taking them for food.

Broussonetia papyrifera (European name, paper mulberry; Maori, *aute*; Marquesas, Niue, *hiapo*; Uvea, *hiapo, tutu, lafi*; Futuna, *lafi*; Tikopia, *fakamaru, mami*).

This tree is probably a native of south-east Asia, but it is almost universally cultivated in the Pacific, and often looks wild. The tree resembles the mulberry, to which, however, it is not closely related. The leaves (Fig. 63) are thin, with toothed edges, and sometimes oval and pointed, sometimes divided into three. The straight trunk is used for poles, but the most important use of the tree, especially in former times, was as a source of cloth (commonly known as *tapa*, or in some areas as *siapo*). This is made by steeping the inner layers of the bark in water and beating them out with a hard-wood mallet.

Calophyllum inophyllum (European name, native almond; Tahitian, *tamanu*, *ati*; Tongan, Samoan, Uvean, Tikopian, *fetau*; Futunan, *tsilo*; Fijian, *ndilo, ndamanu*; Pukapuka, *wetau*).

This is a widespread sea-coast tree growing to a height of 30 to 60 ft. (Plate 30); when old the trunk becomes very thick and the tree has a

wide, much-branched crown, usually leaning towards the sea. The leaves are oval (Fig. 56), rounded at the tip, and are leathery with a shiny surface and very numerous fine, parallel-sided veins. The fruit is round and hard. In Tahiti, the leaves when young and fresh are used medicinally, as also the oil from the seed kernel. In Fiji, this oil is used as a liniment for

Fig. 63. *Broussonetia papyrifera*, paper-mulberry tree

One of the most commonly cultivated trees of the Pacific islands. The leaves vary in shape, being sometimes divided like that shown in the top right-hand corner of the figure and sometimes undivided. The right-hand twig bears male flowers, the others female flowers. Based on *Andrew's Botanical Repository*, vol. VII, plate 488 (London, 1797); and *Botanical Magazine*, vol. L, plate 2358 (London, 1823).

rheumatism, and the juice from the leaves for relieving eye irritation. The timber which is light pink in colour, and hard, is used in cabinet-making in Fiji; throughout Polynesia it is commonly used for canoe-hulls and wooden bowls.

Carica papaya (European name, papaya, pawpaw; Fijian, *oleti*, and *seaki* or *maoli* in some districts; Tikopian, *naporo*).

This tree (Plate 54) was introduced from America into the Pacific by the early voyagers, and has spread rapidly, especially in areas of secondary growth. It grows as a rule to about 12 to 15 ft. high, with a light pithy trunk, often unbranched to the top. The leaves, which are crowded at the top of the trunk, are large and deeply divided, rather like those of the common fig. The fruit, about the size of a melon, though somewhat less rounded, is dark green until ripe, when it becomes a bright yellow colour; the flesh is somewhat melon-like, but there are a large number of small black seeds in the centre. The fruit and seeds contain a certain amount of pepsin. The milky juice of the unripe fruit is used in Fiji as a remedy for dyspepsia, and the inner bark of the root as a remedy for neuralgia.

Casuarina (European name, Australian oak, she-oak, ironwood ; generally in Polynesia, *toa* ; Tahitian, *'aito*—because a personal name with the word *toa* in it was adopted about two centuries ago by the Pomare family of chiefs, and respect for them made the people change the name of the tree).

Trees of this genus are distantly related to the English oaks, beeches, etc., but have more the appearance of conifers. The twigs are green and switch-like, the leaves being barely perceptible since they have been reduced to very small teeth. The commonest species is *C. equisetifolia* (Fig. 66), a characteristic seashore tree in the Western Pacific. A number of other species are found inland in New Guinea and New Caledonia. The wood, which is very close-grained and hard, was formerly widely used for bark cloth mallets, and also for spears and clubs.

Colocasia antiquorum (commonly known as *taro*, its general Polynesian name ; Mangaian name, *mamio* ; Futunan, *talo* ; Pukapuka, *wawa*, *talo* ; Fijian, *kalo*, *ndalo*, *ndoko*—in some districts only ; Trobriands *uri* ; Blanche bay, *pa*).

This common cultivated plant with many varieties is widespread throughout the Pacific islands. It is an aroid, growing up to about 4 ft. high, with fleshy leaf stems and large smooth-veined, heart-shaped leaves (Fig. 62, Plate 115). The corm is oval, a few inches in diameter, and rather like a large potato, but with a coarser skin and hair-like rootlets. In Hawaii, *taro* which grows wild propagates by side-shoots, but the cultivated varieties are usually propagated by cutting off the top of the corm and re-planting it, with the attached leaves. The plant varies in its preference for water, but most varieties are grown in swampy ground or in irrigated land. The corm is one of the staple foods of the Pacific island peoples, and the leaves are often also cooked as greens.

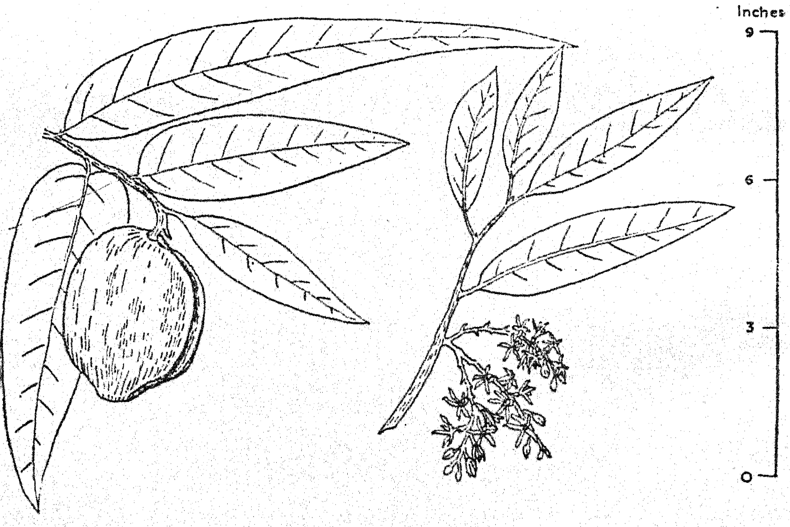

Fig. 64. *Inocarpus edulis*, Tahitian chestnut

A large evergreen tree with edible nuts. The flowers are whitish. Drawn from a specimen in the Cambridge University Herbarium and from E. J. H. Corner, *Wayside Trees of Malaya*, vol. 1, p. 395 (Singapore, 1940).

Cordia subcordata (Tahitian name, *tou* ; common names in Polynesia, *tou*, *kou* or *kanava* ; Pukapuka, *wakanava* ; Fijian, *kaunimbuka*).

This is a small, rather bushy tree, usually 15 to 30 ft. high, but sometimes more, with oval, bluntly pointed leaves 3 to 6 in. long. It is in general much like both *Hernandia* and *Thespesia*, but is quite distinct from either in its trumpet-shaped orange flowers. The tree in some parts of the Pacific is thought to have been introduced at an early date by the Polynesians, who value its durable, easily worked wood for building houses and canoes. In Fiji, the sticks were rubbed together to produce fire. In Tahiti, the wood is now used by cabinet-makers.

Cordyline terminalis (commonly called *ti* in Polynesia and Fiji ; Uvean, Tongan, *si* ; Futunan, *tsi* ; the closely related *C. australis* is called cabbage tree in New Zealand).

This is a palm-like plant with a branched trunk, growing up to about 12 ft. high, with a long tap-root. The drooping leaves, unlike those of

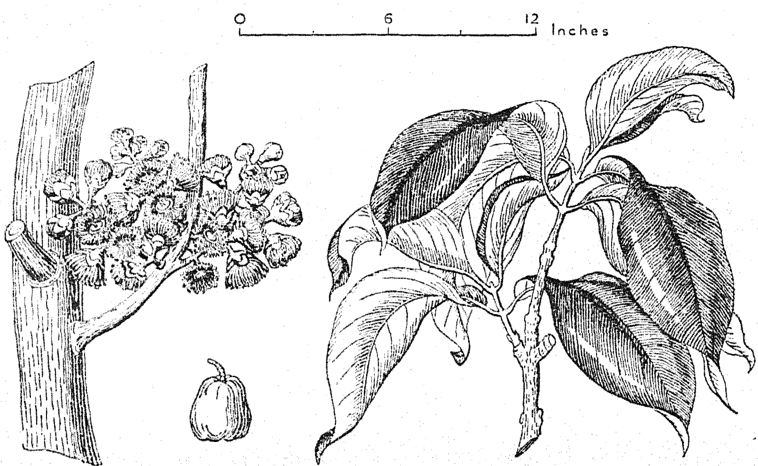

Fig. 65. *Eugenia malaccensis*, rose apple, Malay apple

A tree in which the flowers are borne on the lower leafless part of the twigs. The flowers are crimson and the pleasant slightly acid fruit tinged with pink or crimson. Based on *Andrew's Botanical Repository*, vol. VII, plate 458 (London, 1797).

palms, are sword-shaped and undivided. This is one of the important economic plants of the Polynesians, who use the leaves as wrappings for fish, etc., and the root as a food. A fermented drink is sometimes also prepared from the root, which is very sweet when cooked.

Dioscorea (European name, yam ; known generally in Polynesia as *uwhi*, *uhi* or *ufi*, according to dialect, but some large varieties are termed *kape* or *'ape* ; Fijian, *kawai*, *kaile*, etc. There is a great range of Melanesian and Papuan names for the yam.)

Yams are climbing plants (Plate 116), with tubers, but there are many species and varieties, both wild and cultivated. Some have aerial as well as subterranean tubers, but the tubers of most are subterranean only. The

latter vary greatly in size. Many are about as big as a very large potato or dahlia root, but others are long and comparatively thin. Some tubers grow to a huge length—examples measured have been 10 ft. and 11 ft. long, and nearly as thick as a man's thigh. The leaves of the plant are usually heart-shaped and small, averaging about 6 in. long. The tubers of many kinds are one of the staple foods of the Pacific, especially in Melanesia and parts of New Guinea, but some of the wild types are useless and even poisonous.

Eugenia malaccensis (European name, Malay apple, rose apple; Tahitian, *'ahia*: Hawaiian, *ohia*; Fijian, *kavika*; Tikopian, *kafika*).

This tree grows to a height of about 60 ft., and has large dark green drooping leaves (Fig. 65). The crimson-pink flowers grow in clusters on the branches behind the leaves. The fruits are about 2 in. long, pear-shaped or oblong, and either crimson or white splashed or striped with crimson; they are juicy and have a pleasant, slightly acid flavour.

Guettarda speciosa (Fijian name, *mbuambua*; Gilbert islands, *uri*).

This is a tree 15 to 30 ft. high, providing a useful hardwood; it grows mainly on sandy shores. The very large, broadly oval, leaves may be recognized by their heart-shaped base and opposite arrangement on the twigs. The tree bears masses of very fragrant white flowers, opening at night; they are tubular like those of a *Gardenia*.

Hernandia ovigera (=*H. peltata*. Fijian, *evueva, uviuvi*; Tokelau and elsewhere in Polynesia, *puka*; Pukapuka, *pukama*).

This is a tree of the seashore, with rounded crown, sometimes growing to a height of 45 ft., but generally much less. It can be known from all

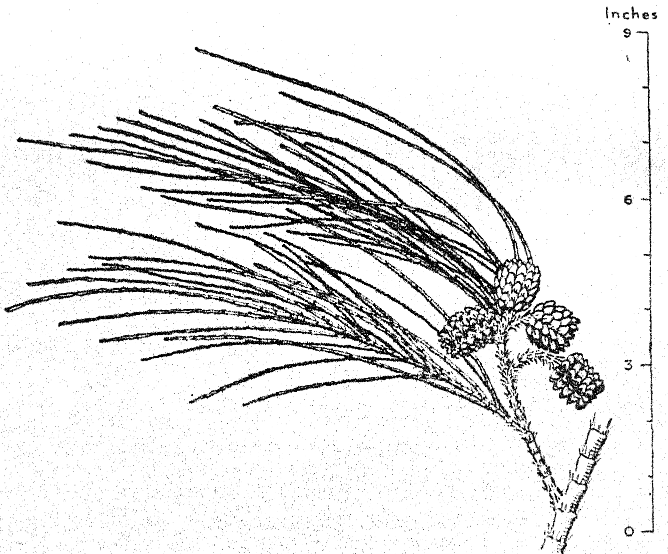

Fig. 66. *Casuarina equisetifolia*

A tree with green, apparently leafless twigs. A common species on sandy beaches in the warmer parts of the Pacific, sometimes planted inland. The figure shows the cone-like female inflorescence. Drawn from various sources.

other common trees of its habitat by the pointed, red-veined leaves, with the leaf stalk attached towards the middle, as in the garden *Nasturtium*. In Fiji, the fruits are used medicinally, and in Polynesia generally the timber is often used for canoe floats, being light and straight-grained, though not very durable.

Hibiscus (named generally in Polynesia *hau* or *fau*; Tahitian, *purau*, *fau*—formerly also *hau*; Mangaian, *'au*; Niue, *fou*; Fiji, *vau*).

The garden hibiscus, *H. rosa-sinensis*, is one of the commonest cultivated shrubs, as in most other parts of the tropics, but it is probably not a native of the Pacific. Of the several native species the most important is *H. tiliaceus* (Fig. 67A). It is a much branched shrub or tree, sometimes reaching a height of 30 ft. It is a characteristic plant of muddy places by the sea or by brackish water, and also often forms the main constituent of extensive woods inland, as in Tahiti and the Marquesas. It and the coconut are by far the most important fibre-producing plants of the Pacific. From the inner bark string and rope are manufactured by the natives, and pads of it are used as wringing material, when coconut cream is expressed or kava made (vol. II, p. 617). In Tahiti the finely braided fibre was formerly made into clothing. The wood is used in boat-building and house-building and for canoe paddles, as well as for firewood. The flowers, which are yellow with a maroon eye, are like those of *Thespesia* (Fig. 67B) and are

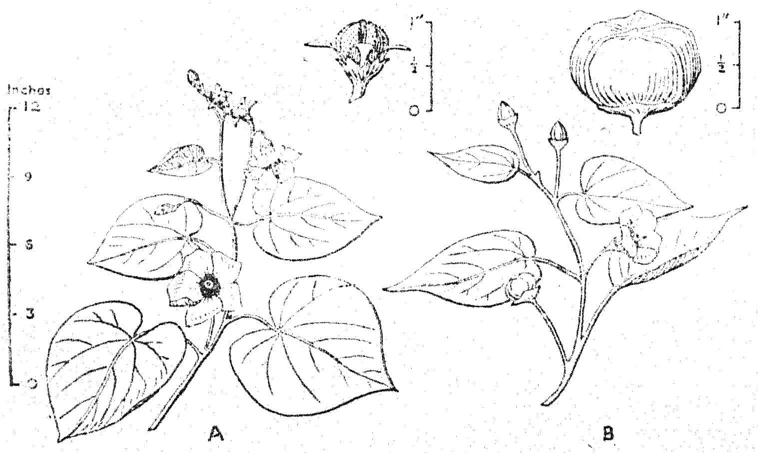

Fig. 67. *Hibiscus tiliaceus* (left) and *Thespesia populnea* (right)

Two very similar small trees, both very common in beach forests and on coasts in the Pacific islands. The two trees can be distinguished by the shape of the leaves and by the shape and size of their fruits, as well as by their flowers. Based mainly on E. J. H. Corner, *Wayside Trees of Malaya*, vol. I, p. 444; vol. II, plate 133 (Singapore, 1940).

often worn as ornaments. The leaves are similar in shape to those of the English lime tree, with a felt of grey hairs beneath; in the Cook islands they are used as plates.

Inocarpus edulis (Fig. 64. European name, Tahitian chestnut; Tahitian, *mape*; Tonga, Rarotonga, Tikopia, etc., *ifi*; Mangaia, *i'i*; Fijian, *ivi*).

This tree commonly grows to a great height, often reaching 60 ft. The

leaves are leathery and elliptical, with tapering points, and sometimes are as much as 14 in. long. The fruits, hanging singly or in clusters from slender twigs, are of an irregular kidney shape, with one seed in a thick fibrous pod, which is several inches long. The seeds, which are commonly used as food, especially when root crops are scarce, taste rather like chestnuts when cooked. The bark of the tree gives out a red sap when cut. The trunk, like that of many other tropical trees, has thin flanges or buttresses, which were often beaten as gongs in olden days. The timber is tough, but because of the size of the buttresses is of little commercial value.

Ipomoea batatas (Fig. 68. European name, sweet potato; Maori, Rarotongan, *kumara*; Tongan, *kumala*; Tahitian, '*umara*; Samoan, '*umala*; Hawaiian, '*uala*; Mangaian, *kuara*; Fijian, *kumala, kawainivulagi*).

This creeping plant is a convolvulus, with deeply divided leaves about 6 in. long, and subterranean tubers rather like those of the potato, though

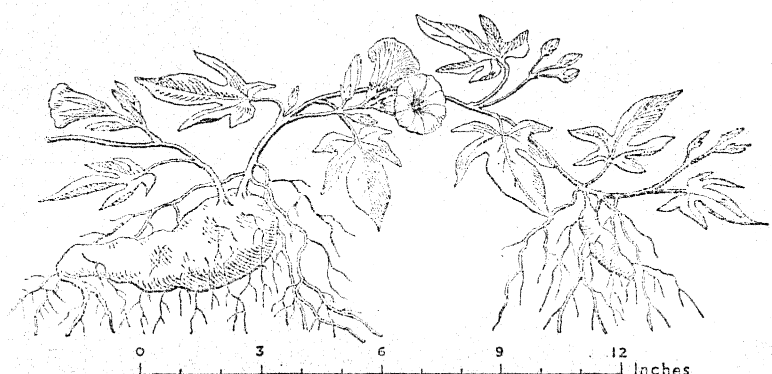

Fig. 68. *Ipomoea batatas*, sweet potato

An important root crop of the Pacific. Based on Fiori and Paoletti, *Flora italiana illustrata*, part 2, fig. 2847 (Padova and Udine, 1899–1904); and *Addisonia*, vol. IX, plate 306 (New York, 1924).

thinner and more pointed, and often curved. There are many varieties, some having tubers, with pink, yellow or purple flesh. The plant, which is commonly cultivated throughout the Pacific, is usually propagated by means of cuttings from the stem, each with a pair of leaves attached. It grows best in a warm somewhat sandy soil and is an important food plant in Polynesia; it was formerly a staple food for the Maori in the north of New Zealand.

Lantana camara (Fig. 61). This is a pretty, spreading bush, about 3 ft high, with clusters of small yellow, orange, pink or white flowers. Originally a native of tropical America, it was introduced into the Pacific as a garden plant, and, as in Malaya, it has spread rapidly and become in places a serious pest.

Metrosideros (Hawaiian name, *lehua*, *ohia*).

The various kinds of *rata* and the 'Christmas tree' of New Zealand belong to this genus. *M. polymorpha* is the commonest of several species found in the Pacific islands. It is an exceedingly variable plant, ranging in

size from a small creeper a few inches long to a massive forest tree 100 ft. high. The tuft of crimson stamens in the flower is characteristic, but the size and shape of the leathery leaves is very variable. As a tree it is an important constituent of rain forest in most of the Pacific islands, especially in the Hawaiian group.

Morinda citrifolia (Tahitian name, *nono*; Pukapuka, Niue, *nonu*; Hawaiian, *noni*; Fijian, *kura*).

This is a straggling shrub or small tree on coral islands and sea beaches. It is known by its very large glossy leaves in opposite pairs, four-sided twigs, and the curious greenish fruit, rather like an unripe strawberry in appearance, with a pungent smell. The pulp of the fruit was formerly eaten in Tahiti, after being passed through water. In Tahiti, the leaves are used to give a flavour to fish in cooking, and also medicinally, to reduce inflammation. In Fiji, the young shoots of the plant give a basic medicinal oil, for use in ringworm and other diseases. But the most important use of the plant in most parts of the Pacific is for dye; the roots give a yellow dye, and the bark a red one.

Musa (banana, plantain; Tahitian name, *mei'a* for the cultivated varieties and *fe'i* for the wild mountain varieties; known generally in western Polynesia as *futi*; Mangaian name, *koka*; Fijian, *vudi*; Trobrionds, *usi*; Blanche bay, *wudu*).

There are many varieties of the banana recognized by the natives. Some are known to be of recent introduction, others are long established, but possibly none—not even the wild varieties—are truly native to the Pacific. They vary considerably in the size, length, shape and colour of the fruit, which is one of the staple Pacific island foods. The leaves are commonly used as wrappings for food and small articles.

Palms.

Palms, both wild and cultivated, are a conspicuous feature of the landscape, especially on small islands or in coastal districts. The most widespread is *Cocos nucifera* (coconut; general Polynesian name, *niu*; Trobriands, *nuya*; Blanche bay, *lama*) the most important economic plant of the Pacific. Its original home is uncertain, some views inclining to tropical America, others to south-east Asia as the source. Though coconut palms are found on almost every island large enough to support any land plants, they are probably not native there, and have nearly always been planted. Coconuts are often carried long distances by sea, but rarely succeed in establishing themselves on the shore without assistance. The liquid in the nut is used as a drink, sometimes taking the place of water, and the flesh of the nut is used at different stages for food, as well as providing copra, one of the basic Pacific export articles. The shell of the nut provides drinking vessels, spoons, ornaments and fuel; from the husk is made a kind of sennit cord. The leaves are used as thatch for houses and, when dry, as torches; the leaflets are plaited into baskets, fans, eye-shades, mats and wall-screens. The dry spathes are used for fuel, and the fibrous material which covers the base of the fronds where they are attached to the trunk is used as straining-cloth and for bags. The trunk is utilized as timber, and there are a number of other uses to which parts of the palm are put.

Other important palms, especially in the Western Pacific, are: the areca, which provides the nut commonly used in betel-chewing; the sago, from the trunk of which a flour is extracted; and the nipa, which like the sago grows in swamps, and also like it provides leaves which are used as thatch.

The indigenous palms of the Pacific are almost all endemics of a single

island or group; Lord Howe island, for instance, has no less than four species not found elsewhere.

Pandanus (Plates 52, 55). European name, screw pine; Polynesian name, *hala*, *fara* and other variants, with *kiekie* for some species; Trobriands, *kayburiburi*; Blanche bay, *waum*, *marita*).

The many species of pandanus, though called screw pines from the twisted arrangement of the leaves, are not in any way related to the true pines. They are all shrubs or trees with narrow saw-edged leaves and slender branched trunks supported on a mass of straight stilt roots. The fruit somewhat resembles a pineapple in appearance, but is formed of many separate hard segments. Species of pandanus are very numerous on both the 'high' and the 'low' islands and are often abundant enough to form a striking feature of the landscape. One of the most widespread species is *P. tectorius*. The pandanus plays a very important part in native life, providing the people with mats, thatch, screens and sometimes clothing from the leaves; scent from the male inflorescence and various types of food from the fruit, which is rich in starch and glucose. On many of the low coral islands, where other cultivated plants can be grown only with difficulty, the pandanus fruit is an important part of the diet.

Pisonia grandis (=*P. inermis*. A common Polynesian name is *puka*).

This is a tree varying in height from about 15 to 80 ft. and forming woods or groves on coral islands and other dry places. The leaves are thin, elliptical and oblong, arranged in opposite pairs, and about 3–6 in. long and 1 to 3 in. wide. The fruits exude a gum which is used as a bird-lime in Hawaii. The trunk is thick, but the wood is soft and not greatly used, except for canoe floats.

Pemphis acidula (sometimes known as ironwood).

This is a bush, occasionally as much as 20 ft. high, which often covers large areas on coral islands. It provides good firewood and the very hard wood is used by the natives for carving and formerly for weapons. The main trunk is stocky, the branches gnarled and twisted, bearing small white flowers and tiny silky grey leaves. It has rather the appearance of an overgrown heath.

Scaevola frutescens (=*S. Koenigii*. Sea-lettuce tree).

This is one of the commonest bushes of the seashore, often covering large areas on coral islands. The leaves are from about 3 to 10 in. long, light green and fleshy, tapering gradually backwards to the stalk. The flowers (Fig. 53) are white or pale lilac, tinged with yellow. The berries, white when ripe, are crowned with the remains of sepals, like an apple. Other species of *Scaevola* grow inland in Samoa, Hawaii and other large islands.

Spondias dulcis (=*S. cytherea*. Often known to Europeans as vi-apple; Tahitian and Cook islands name, *vi*).

The tree is large and spreading, from 40 to 50 ft. high, and is one of the few deciduous trees of the tropical Pacific. The leaf is pinnate, with a terminal leaflet. The flowers are small and whitish. The fruit, which hangs in clusters, is like a medium-sized apple, smooth-skinned and of a rich golden colour when ripe. The skin is leathery and the flesh is aromatic and of an agreeable flavour, slightly acid. The fruit is regarded as a delicacy. It has a large spiked core, with several pear-shaped seeds. The wood of the tree is soft and of little value as timber.

Terminalia catappa (Fig. 57). Tahitian name *autara'a*; Fijian *tavola*.

This tree is commonly planted by roadsides throughout the tropics and

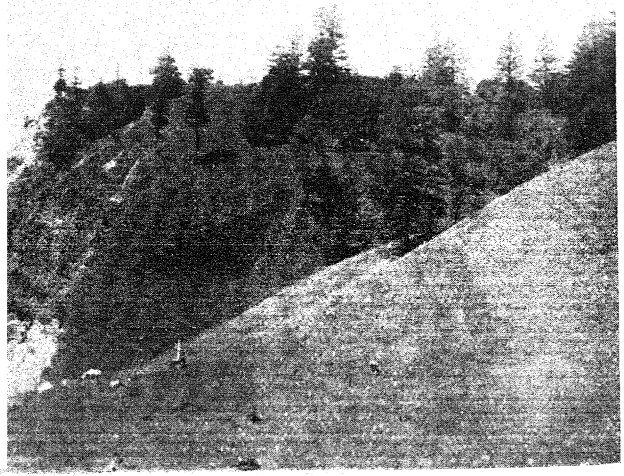

Plate 53. Norfolk island pines (*Araucaria excelsa*), Norfolk island

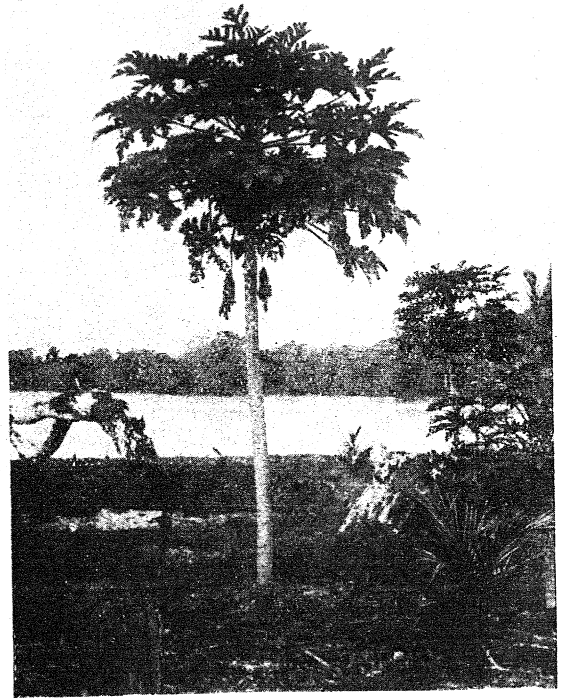

Plate 54. The papaya or pawpaw (*Carica papaya*)
A commonly cultivated tree of the Pacific. The short unbranched trunk and large divided leaves give it a characteristic appearance. The fleshy fruits may be seen below the lower leaves.

Plate 55. *Pandanus mei*, Hivaoa, Marquesas
This species is endemic to the island.

grows wild on sandy beaches in the Western Pacific. It can be recognized by the stiff outstanding branches arranged in tiers, and the broad oval leaves which are borne in rosettes and turn red before falling. It resembles *Barringtonia*, but has less pointed leaves, and its flowers are quite different. The fruit is edible and the wood, which is close-grained and variegated with shades of brown, is used in Tahiti by cabinet-makers and in Fiji for gongs. In Fiji also the leaves are used medicinally.

Thespesia populnea (Tahitian name, *miro*, *amae* ; Hawaiian, *milo* ; Easter island, *makoi*).

This is very like *Hibiscus tiliaceus*, but it is a tree rather than a shrub, and the leaves are more triangular, with longer points—like those of the black poplar rather than those of the lime. Moreover, they are not hairy beneath. The tree grows chiefly on sandy shores. Its handsome dark wood is used for carving, and in some islands poles of it are used as rods in bonito fishing.

Tournefortia (*Messerschmidia*) *argentea* (European name, tree heliotrope ; Tahitian name, *tahinu* ; Pukapuka, *taeyinu* ; Gilbert islands, *ron* ; Fijian *evu*, also *roronimbembe* and *kauniyalewa*, the second name meaning 'butterfly's rest', and the third referring to the use of the plant medicinally for women's complaints).

This is a tree of dry sandy ground near the sea, and is often the only tree on small coral islands. The leaves (Fig. 54) are narrowly elliptical, and are conspicuous for their thick covering of silky hairs. The flowers are mauve and are similar to those of the true heliotrope, to which the tree is related.

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' Floras '

The identification of plants from the Pacific is often a difficult matter and is in general a task for the expert with access to one of the great herbaria such as those of Kew and New York; the Bishop Museum herbarium at Honolulu is the only large collection entirely devoted to the Pacific. There is no general ' flora ' of the Pacific, but the following regional ' floras ' are of importance:

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Chapter VI

FORESTRY

Destruction of Forests : Present Situation : Bibliographical Note

Forests are necessary to human prosperity for several reasons. In the Pacific islands they are a source of food and other materials, such as timber and fuel, and they play a part of equal or greater importance in conserving and regulating water supplies. In rugged mountainous country subject to heavy rainfall, such as the 'high' islands of the Pacific, their value in protecting the soil against erosion can hardly be over-estimated.

Over by far the greater part of the land area of the Pacific, forest is the natural climax vegetation. Except on the smaller coral islands, which are, and always have been, poorly provided with large trees, climate and soil are everywhere suitable for trees to grow; until quite recent times a large percentage of the surface was in fact forest-covered. The forests are mainly evergreen rain forests, consisting mostly of slow-growing hardwoods forming mixed stands with no single dominant species. The Western Pacific islands, particularly New Guinea, New Caledonia and the Fiji group are, however, fortunate, and indeed almost unique among tropical countries, in possessing also forests rich in conifers, such as the kauri and the hoop pine, which yield softwoods. Because they are easily worked and even in grain, these coniferous timbers are used in far greater quantities by modern communities than are the generally more durable hardwoods.

Destruction of Forests

Though forests at one time covered so large a part of the land area, the Pacific islands, far from being one of the world's great timber-producing areas, are today for the most part not even self-supporting in timber. In many islands soil and water supplies have suffered gravely, or are now menaced, by the destruction of the forests. Except in New Guinea and some of the neighbouring groups of islands where the population is still sparse and primitive, the present area of forest is everywhere inadequate to meet the needs of the inhabitants and to safeguard the prosperity of agriculture. The chief

aims of forestry in the Pacific, as in most other parts of the world, must be to preserve the forests that remain and to increase their area by reafforestation and the planting of denuded land.

The destruction of the forests is only partly due to the felling of trees for timber and the clearing of forest land for agriculture. In most parts of the Pacific large areas have been deforested by semi-wild domestic animals, such as pigs and sheep, which eat the tree seedlings and prevent the forests from regenerating. Some idea of the magnitude of this problem will be given when it is stated that in the Territory of Hawaii, which has the longest established and most highly organized forestry service in the Pacific, 22,364 goats, 6,483 sheep, 4,887 pigs and 497 cattle, as well as a few horses and donkeys, were killed in forest reserves in the years 1928–30.

Though the coming of the European and his domestic animals has accelerated forest destruction greatly, the process was begun much earlier by the native inhabitants. Already at the time of their discovery by Europeans, many of the less heavily wooded islands had been practically denuded of trees, so that timber had become a highly prized commodity. Easter island, for instance, which is believed by botanists to have been wooded at the time of its first colonization, soon became almost treeless. When Du Petit-Thouars visited it in 1836–39 the natives were far more eager for wood than for scissors or knives. The wood hunger of the Easter islanders still persists, and every piece of wood coming to the island is carefully preserved. The rapid depletion of the timber on many islands soon led to the export of timber from the better-wooded islands. Fiji, still today better provided with forests than most of the neighbouring groups, in pre-European times exported logs to Samoa and Tonga for making war canoes. To some extent the meagre timber supplies could be supplemented with driftwood; some of the most famous of the ancient Hawaiian war canoes were made of Douglas fir which had drifted across the sea from western North America.

Sandalwood

The first Pacific timber to play a part in European trade was sandalwood, obtained from several species of small trees belonging to the genus *Santalum*, native in the open forests of the dry zones of Hawaii, Fiji, New Guinea and other islands. Sandalwood is one of the world's most expensive timbers, as the heartwood yields a fragrant oil and is itself in great demand, particularly among the Chinese, who use it in religious ceremonies. Sandalwood trees

were never very plentiful and the supply soon became exhausted. (For the sandalwood trade see pp. 269–71, 291–2.) In Fiji, the *yasi* or Fijian sandalwood (*Santalum yasi*) was at one time fairly abundant in the Mbua province of Vanua Levu, but even by 1816 it was becoming scarce. In 1929–30, 50 tons were exported from Tholo West, after many years during which the sandalwood trade seemed to have disappeared for ever. The tree was by then all but completely exterminated and in 1930 the government took the long-overdue step of prohibiting the export. The history of sandalwood in Hawaii is very similar but forest reserves have been created in which the tree has increased in abundance very satisfactorily, and before long it may again become an article of export. The native Hawaiian *Santalum Freycinetianum* has been supplemented by planting the Indian *S. album*, which grows faster and seems well suited to the soil and climate. Sandalwood was once one of the most important exports of Papua, fetching as much as £40 per ton; but though the supply is by no means exhausted most of the trees remaining are in the savannah and gully forests some distance from the coast, and are therefore comparatively inaccessible. Small amounts of sandalwood are still left in the New Hebrides and New Caledonia.

Beginnings of Conservation

Throughout the nineteenth century and the first quarter of the present one the story of the Pacific forests was one of wasteful exploitation and destruction by natives and Europeans alike. Timber was recklessly felled without any thought of replanting or maintaining a steady supply. Forests were destroyed at an ever-increasing rate by clearing, shifting cultivation, and the ravages of domestic animals. Only very recently has it begun to be realized that the protection of forests is economically vital, not merely in order that the islands may become self-supporting in timber, which in the future may not be so easily obtainable from abroad, but to provide for the conservation of the soil and water necessary for agriculture. The first administration to become alive to the dangers of deforestation was that of the Territory of Hawaii, where the sugar planters have long realized the necessity of forests as the collectors and conservers of the rain water used for irrigating the cane fields. An efficient forestry department has been active here for many years, the first forest reserve being established in 1904. Other areas have been

slow to follow suit; in Fiji a forestry department was not created till 1937, and in the Territory of New Guinea not till 1938.

Present Situation

The present position of forestry in the Pacific is so different in different areas that they must be dealt with separately.

Hawaii

In the Territory of Hawaii the total forest area is 1,100,000 acres, of which 275,000 acres are in accessible situations. This is equivalent to rather more than a quarter of the land area, or 2·6 acres of forest per head of population. There are no native conifers or softwoods of any kind; the natural forests consist of slow-growing hardwoods, of which the most useful are the *koa* (*Acacia koa*) and the *ohia lehua* (*Metrosideros polymorpha*). Both of these produce timbers which can be used for making furniture, ukuleles, veneers for radio cabinets, flooring, etc., but are not suitable for large-scale constructional work. Redwood and Douglas fir can be imported cheaply by schooner from the United States for building purposes, and it is considered more economical to do so than to attempt to produce softwoods locally. The *algaroba* (*Prosopis juliflora*), introduced into Hawaii in 1828, has been spread by animals and now covers over 100,000 acres, chiefly in the dry lowlands. This tree is the chief source of firewood, and large quantities are used particularly by the United States Army.

Because of the limited usefulness of the native timbers and the mountainous nature of the country, forest policy in Hawaii aims primarily at conserving and regulating the run-off of water, and not at timber production. About 10,000 board-feet of *koa* wood are cut yearly, and small quantities of this and other native hardwoods are used locally. A very small amount of timber is exported to the United States. In the government-owned forests, which form 65% of the total reserved area, no timber at all is cut.

The main work of the forest administration consists of reserving and protecting the existing forests and replanting treeless land, particularly on watersheds. In 1931 there were 63 forest reserves on the five largest islands, varying in size from 10 to 122,782 acres, the total reserved area amounting to 1,021,314 acres. Reserves not belonging to the government are mostly owned by sugar plantation companies and large estates. The actual field work of the forest

service consists mainly of fencing, destroying harmful animals such as goats and sheep, and planting denuded areas. The chief species planted are introduced trees such as American white ash, and eucalyptus and various other trees, many of them imported from India and Australia. These foreign trees grow faster than the native species and seem well suited to Hawaiian conditions. There is no unfavourable season for planting, so it can be carried on all the year round. The seedlings are raised in flats and pricked out into boxes or rejected cans, which can be obtained free of charge from the pineapple canneries; the soil used is carefully sterilized to kill pests. The young trees must be planted out with their ball of earth, as trees planted in the usual way with bare roots do not survive the drying winds and scorching sun. Special attention is given to gulleys and other ground bared by erosion; the Australian tree *Casuarina glauca* is particularly useful on such land. Some burned or otherwise denuded areas have been successfully afforested by scattering tree seed from aeroplanes. Apart from wild animals, one of the main enemies of the forests is the *uluhi* (staghorn fern, *Gleichenia linearis*), which, as in other parts of the Pacific, forms dense thickets which spread very rapidly. In droughts these thickets become so dry that they catch fire very easily; they also tend to invade the forest, smother the young trees and prevent regeneration. No successful way of controlling this pest has yet been found.

The forest administration consists of the territorial forester with four trained assistants, one to each of the main islands. In addition, there are 18 forest rangers and 64 men engaged in tree planting and tending the nurseries (1931 figures). The cost of the work is met by appropriations made by the local legislature and by a grant of $2,000,000 from the federal government under the Clarke-McNary law.

New Guinea

Conditions in New Guinea make the sharpest possible contrast with those in Hawaii. Here the greater part of the land is forest-covered; the population is relatively very sparse and problems such as erosion and water conservation are not yet urgent. The forest can therefore be regarded mainly as a source of timber, for both local use and export. The forests are mainly mixtures of many species of hardwoods, some of them, such as the *taun* (*Pometia pinnata*) and the 'New Guinea walnut' (*Dracontomelum mangiferum*),

of fairly good quality. The best hardwoods, for instance, the *kamarere* (*Eucalyptus deglupta*) of New Britain, and *Afzelia bijuga*, occur too locally or in too small quantity to be exploited economically. One timber tree, the *erima* or *ilimo* (*Octomeles sumatrana*), which produces a light-coloured, light-weight plywood of fairly general utility, is exceptional in being social, sometimes growing in nearly pure stands. Besides these broad-leaved trees, New Guinea possesses fairly large quantities of valuable coniferous softwoods, of which the best are the two kinds of hoop pine, *Araucaria Cunninghamii* and *A. Klinkii*. These conifers are found in the mountains, generally above 4,000 ft., and are therefore often difficult or impossible to exploit. In some places, however, they have provided a large amount of timber for local use—for instance in the Wau goldfield, where several small towns have been built largely of *Araucaria* timber taken from the neighbouring forests and sawn up by machinery imported by air.

The export of timber from New Guinea is handicapped by the scattered and often inaccessible supplies, by the distance of suitable markets, and by the proximity of Australia, which produces some of the world's best hardwoods. In recent years, however, the depletion of home-grown supplies has led Australian sawmillers to look further afield for supplies, and this has led to the establishment of a number of sawmills in the coastal areas of New Guinea. Timber exports from the Territory of New Guinea, which in 1933–34 were valued at only £180, rose in 1937–39 to £6,030 of logs (equivalent to 3,103,996 superficial ft.) and £480 of sawn timber.

In 1925 a lengthy report was issued on a survey of the forests of Papua and the Territory of New Guinea by C. E. Lane-Poole, Inspector-General of Forests in the Commonwealth of Australia. One of the recommendations of this report was that a staff of qualified foresters should be set up. This recommendation was not carried out till 1938, when two Australian graduates were appointed. The most important duty of these officers, apart from exploration and detailed survey of the forests, has been to control exploitation by a system of licensing and to introduce a regular inspection of logs intended for export—the reputation of New Guinea timber having suffered in the past because logs badly infested with borers had been placed on the Australian market. At the end of 1938, nine sawmills were operating in the Territory of New Guinea and about 60,000 acres of government land were held under permit to cut and remove timber.

Fiji

In the Fiji islands the present condition of forestry is to some extent intermediate between conditions in New Guinea and those in the Hawaiian islands as, though there is a fairly dense population there are still considerable areas of forest in accessible situations. These forests are of considerable economic value for supplying timber for local consumption, as well as for maintaining water supplies and protecting mountain slopes against erosion. The total area of the forests is 2,366,000 acres, of which 2,317,000 acres are rain forest and 48,900 acres are mangrove forest. The rain forest consists mostly of hardwoods, none of which are of outstanding commercial value. But in some places there are large quantities of valuable coniferous woods, notably kauri (*Agathis vitiensis*) and *ndakua salusalu* (*Podocarpus vitiensis*)—both useful softwoods for a variety of purposes—as well as *yaka* (*Dacrydium elatum*)—an excellent wood for high-class furniture and similar purposes. *Kauvula* (*Endospermum sp.*) is used locally on a large scale for making cases for bananas, pineapples and vegetables. The sandalwood in the forests of the dry zones has already been mentioned. The mangrove forests of the Rewa delta and Navua are the chief source of fuel in the islands for both domestic and industrial purposes.

Until very recently timber was felled with little restraint by both natives and Europeans ; there was no attempt to maintain a sustained yield or to reafforest denuded areas. The Fijian Kauri Timber and Land Company held a concession to cut timber (chiefly kauri and *ndakua salusalu*) at Nandarivatu in the mountains of Viti Levu. Another concession was held by Pacific Timbers, Ltd., covering 225,000 acres in Vanua Levu, from which nearly all the *yaka* cut in Fiji was obtained. The mangrove forests which, unlike the inland rain forests, belong to the Crown and not to the natives, were exploited under licence in a very wasteful manner, chiefly by Fijians at Rewa and Punjabis at Navua. In addition, Fijians were allowed to take forest produce from the mangrove forests for their own domestic use, but not for sale. In spite of the large amount of native timber available, about two-thirds of the timber consumed in Fiji was imported from Canada. A common complaint was that, though local timber was durable, it was not available in sufficient quantities at the right time.

In 1930–32, R. A. Sykes was seconded from the Nigerian Forestry Department to survey the Fijian forests and draft a forest policy. In this report it was pointed out that the consumption of the best

native timbers greatly exceeded the rate of replacement; unless steps were taken to limit exploitation and replant the forests the useful timber would soon be exhausted. A detailed forest policy for five years in the first instance was suggested, the total cost of which would be £12,500. It was hoped that this would ensure a sustained yield of timber and eventually make the islands self-supporting in timber. The proposed forestry department was not in fact set up till 1937.

Other Areas

Apart from Hawaii, New Guinea and Fiji there is little to note on forestry in the Pacific. Elsewhere, except in New Caledonia, there is practically no organized exploitation of timber, though the kauri concession on Vanikoro should be mentioned. It is evident that the only part of the Pacific which has any prospect of establishing itself as an area exporting timber on a large scale is New Guinea and the neighbouring islands. Even there the nature and distribution of the native timbers make it unlikely that timber exports will ever be very large. For most of the Pacific, as in Hawaii, the function of the forests must be mainly to protect water supplies and soil; most islands can hardly hope to become even self-supporting in timber. Though the Pacific forests are not important as timber producers, they are none the less necessary to local prosperity, and it is to be hoped that rational plans for reservation and reafforestation will soon be put into effect.

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Chapter VII

FAUNA OF THE PACIFIC OCEAN AND ITS ISLANDS

Characteristics of Island Fauna : Changes produced by Man : Distribution of Pacific Land Fauna (Birds) : Life in the Ocean : Pelagic Animals : Animals of the Sea Floor : Animals of the Abyssal Depths : Colour and Phosphorescence : Types of Corals : Growth of Coral Colonies : Animals Associated with Coral Reefs : Mangrove Associations : Effects of Seasonal Changes on Pacific Fauna : Fauna of Economic Value to Man : Bibliographical Note

The animals of the Pacific area are to be found in such a vast range of habitats, from the tree tops of island forests to the ooze at the bottom of the ocean deeps, that it would be quite impossible to give even a brief description here of more than an insignificant fraction of the many very different kinds. All that will be attempted is a general account of the relationships of the animals to their surroundings and to one another in the most important of their many diverse environments. Works giving more detailed descriptions of particular animals are cited in the Bibliographical Note on p. 211.

Characteristics of Island Fauna

The special character of insular faunas rests on the conditions common to all islands—isolation, space restriction, and special insular climates. The fauna found on an island depends particularly on the distance from the nearest continental land mass, and on the length of time since connection with that land existed, if ever ; as well as on such environmental factors as climate and type of vegetation. From a faunistic point of view, islands may be divided into two distinct types, continental and oceanic islands. A continental island has at some time been part of the mainland, and if not too small will contain the same fauna as the land from which it was separated. Ancient continental islands of any size will lack some groups, which have become extinct on the island, or which have evolved on the mainland since the separation took place. On the other hand, primitive forms which have become extinct on the mainland owing to competition with more modern species may survive on islands. An oceanic island is one that has never been attached to a continent, but has been formed independently in mid-ocean by volcanic agency or by the building up of a coral reef. Such an island must originally have been without air-breathing

animals and its land fauna will consist of animals which have been able to cross the ocean by flying, swimming or by some passive means. Animals which are incapable of flight or other aerial transport, or to which sea water is fatal at all stages of life history, are excluded from oceanic islands. Amphibia and many other fresh-water animals seem to be excluded from oceanic islands for these reasons.

Many different kinds of animals are able to reach islands by air. Small forms like weak-flying insects and newly hatched spiders on gossamer threads may be carried to considerable heights by ascending currents of air over land, and before they come down again they may drift for great distances; there is an anti-trade-wind current of air at no great altitude over the Pacific and many small forms may have been carried eastwards by it. The distribution of the fauna of the Pacific islands shows that most forms have arrived from the west, and therefore against the prevailing winds. Birds and more strongly flying insects will be able to fly less aimlessly, and many of them show a tendency to fly against a weak wind. The more strongly flying birds and bats will generally avoid being blown out to sea; but if they are blown out of sight of land by a strong wind the strongest fliers will go furthest before they perish, and will stand a better chance of reaching an island. Finally, we come to birds like the Pacific golden plover and the long-tailed cuckoo, which have such powerful flight and such a wonderfully developed sense of direction that they are able to fly deliberately from the mainland to the furthest islands and back again each year.

Other animals are carried to islands by sea, some by active swimming. There is the example of the Solomon islands' crocodile which came ashore in Fiji and killed several people before it was destroyed. Many small animals are carried about on driftwood. Weevils must often be carried about the oceans in this way, as their larvae frequently live in wood, and this may explain their predominance on many islands; in the Marianas, for example there are more weevils than all other species of beetles put together. Lizards, especially skinks, are widespread in the Pacific islands, but land mammals seem not to be able to survive long on driftwood and are mostly missing. Why snakes are not more widespread than they are is rather puzzling. A boa constrictor was carried 200 miles on a floating cedar tree to St Vincent island in the West Indies, and boas range from New Guinea through the Bismarck archipelago, the Solomons, and the New Hebrides to Fiji and Samoa. Other

snakes are found in New Caledonia and in the Society islands. The sea snakes are naturally much more widely distributed. It should be noted, however, that the normal currents of the tropical Pacific (Figs. 120–1) flow in the opposite direction to that required to account for the distribution of the fauna. Logs from north-west America are washed up on the Hawaiian shores and fish-net floats from Japanese waters also reach these islands. Bottles thrown into the sea off the Central American coast drift right across the Pacific and are collected on the Philippines, the Solomons, or anywhere between these tracks. These are the normal currents today. What currents may flow as a result of cyclonic disturbances or other abnormal conditions, and what the currents may have been in the past, is not known. American elements are absent from the fauna of the Pacific islands other than the Galápagos, Juan Fernández, and islands near the American coast. Probably the distance is too great and the drift too slow.

The islands west of a line drawn from the Bismarck archipelago and the Solomons through the New Hebrides, Fiji and Tonga to the Kermadecs and New Zealand, including the islands named, have a fauna which is clearly the remnant of a continental fauna. The islands to the east of this line are either volcanic like Samoa, or atolls of coral limestone like the Ellice islands, and the ocean is continuously deep here. Fossil-bearing strata are absent from these islands and geologists are not all agreed as to whether there ever was a land mass in the centre of the Pacific or not; but it seems incontestible that the present fauna of these islands is oceanic, and most zoologists are agreed that if there ever was a central continent it must have sunk completely and that neither the present islands nor their flora and fauna are a remnant of a continental mass.

The distribution of the land molluscs of the Pacific islands is interesting in this connection and rather different from that of most groups of animals. Throughout Polynesia (including the Hawaiian islands) the snail fauna is very uniform and at the same time very different from that found elsewhere. The ancient generalized genus *Partula* is confined to Melanesia and Polynesia, but is widely distributed throughout these island groups. On the other hand, many groups which are widely dispersed in the rest of the world, including other oceanic islands—for instance, the Helicidae and Arionidae—are absent. The distribution of the land molluscs is thus consistent with the hypothesis of an ancient continental land mass uniting all Polynesia with Hawaii, and it has been suggested

that the land broke up into smaller land areas in middle Mesozoic times—that is, early enough to account for the absence of mammals and other animals in the area (see Table of the Main Geological Periods, p. 15).

The presence of amphibia in the Bismarck archipelago, the Solomons, and Fiji is very good evidence that these islands are of continental origin. Amphibia, like many other freshwater animals, are unable to survive exposure to salt water and have special difficulty in reaching islands; they are often poorly represented even on undoubtedly continental islands since they are easily liable to extinction and cannot readily be replaced. There is practically no standing fresh water in the way of pools or ponds on small islands, and heavy rains and steep hills combine to form torrents which would wash away the tadpoles of ordinary amphibia rather than allow their leisurely development. The amphibia of Melanesia are able to survive under these conditions because they have dispensed with a free-swimming tadpole stage. The evolution of these special methods of reproduction can only have proceeded gradually, and must have taken place while the islands were separating off from the mainland and getting smaller.

Freshwater molluscs are very rare and aquatic insects are absent on most of the small islands. Some of the older oceanic islands have freshwater snails which have evolved from marine forms. The Hawaiian islands have few aquatic insects, no caddis flies, only four species of water beetle, and two aquatic *Hemiptera*. Dragonflies with their great powers of flight are, however, widespread on islands. Most of the few freshwater fishes found on oceanic islands have originated from the sea, and the same is true of the prawns found in island streams.

Island species are isolated from their fellows on the mainland or other islands and tend to evolve along independent lines. The more effectively and the longer an island has been separated from the nearest inhabited area the more endemic species it will have; but the accessibility of a particular island from other more thickly populated areas will differ for the different groups of animals. If an archipelago is compared with a neighbouring mainland it is evident that the isolation of the separate islands has led to the evolution of many separate species, many of which are confined to single islands. The Philippines, for example, have over 1,000 species of land snail, while there are only about 600 in the whole of Indo-China and Siam. The amphibia of the Solomon islands,

which are Papuan and not Australian in origin, are fairly homogeneous and species which are found in the Solomons are not found in New Britain and New Ireland. This indicates that for a long period the Solomons were contiguous with one another.

On ancient islands well isolated from the continent the genera are often split up into many species. The Hawaiian islands—very ancient volcanic islands 2,000 miles from the nearest land—have a very high proportion of endemic species of land snails, birds, insects and fish. There is a primitive family of land snails represented by fourteen genera, and a great many species—of which none, either living or fossil, are found anywhere else. Some of the genera are confined to single islands and each of the valleys radiating down from the mountains is often characterized by its own series of species. The weevil-like genus *Proterhinus* has evolved on the Hawaiian archipelago and there are about 150 species endemic to these islands. A few species have spread out from there, one has been found in Samoa, one in the Phoenix islands and two in the Marquesas; but none is known elsewhere.

The Galápagos islands are not so completely isolated and two ocean currents flow past them, one (in their winter) from the coast of Peru, and the other (in their summer) from the Gulf of Panama. The 46 species of land snail, whose dispersal may have been favoured by these currents, are mostly endemic, but they all belong to Central or South American genera. The same picture is given by the rest of the Galápagos fauna.

Isolation on islands affords effective protection against the entrance of competitors, and forms which have succumbed in the struggle with more advanced species on the continent may survive on islands. Moreover, the absence of native land mammals other than bats on most islands is specially favourable for bird life. The rather helpless pigeons increase in numbers from the Malay archipelago eastwards as the mammals decrease, and are strikingly developed in Polynesia, where no native land mammals exist (apart from bats). The distinctive Didunculidae family of pigeons is confined to two islands of Samoa.

The absence of predators makes it possible for island birds to develop unusual colours. The evolution of the birds of paradise in New Guinea and the immediately adjacent islands may be explained in part in this way. (The New Guinea land fauna is described in vol. IV, pp. 115–9.) For the same reason a number of island birds are flightless. Flightlessness in birds and insects on islands is, however, characteristic especially of small level islands in stormy areas. The

Plate 56. A valley in the mountains of Hawaii
The vegetation is luxuriant and includes many ferns. The large leaves belong to a species of *Gunnera*.

Plate 57. Racing crabs (*Ocypoda*), Gilbert islands

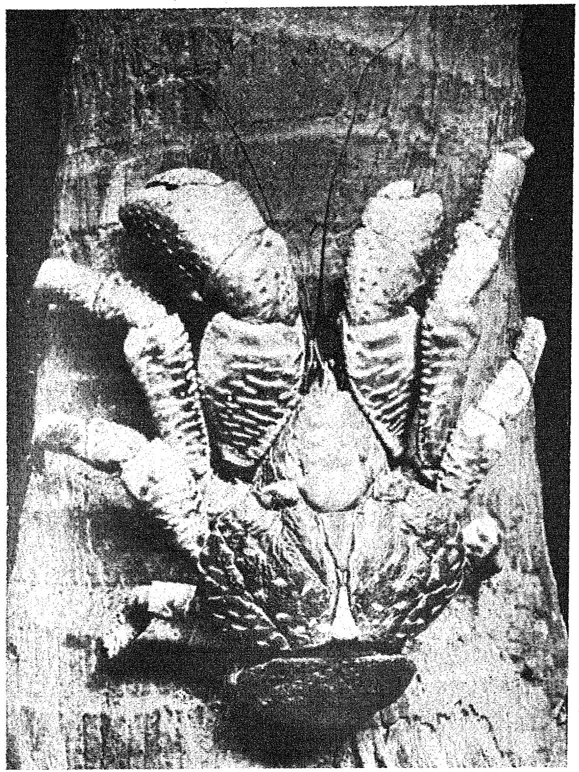


Plate 58. Coconut crab (*Birgus latro*)
The crab is shown climbing a palm trunk. This species is said to be able to split open the nuts to extract the kernel.

most striking examples are found in the Kerguelen, Crozet, and other sub-antarctic islands, and the phenomenon is not quite so conspicuous in the Pacific.

The size of island animals frequently differs from that of their mainland relatives. Reptiles, especially tortoises and lizards, tend to be very large. The largest living land tortoises are found in the Galápagos, which also have two large species of iguana. These may well be relics of faunas which were originally more widely distributed; but the large geckos and skinks of, for example, New Caledonia, suggest a real connection between insularity and large size. On the other hand, many mammals become smaller when confined to islands.

The constant humidity of islands, together with their relatively long coast line, favours the land crustaceans. Small tropical islands have great numbers of land crabs—hermit crabs, racing crabs and coconut crabs (Plates 57, 58). The hermit crabs adopt the shells of land snails in the Solomons and other islands. All land crabs migrate to the sea to breed and their larvae live in the surface waters and are carried from island to island by ocean currents. Most of the species are, for this reason, widespread in the Pacific islands.

Changes Produced by Man

The absence of native predators and the lack of competition with modern species, while it has permitted primitive species to survive on islands and has allowed the development of lax habits and bizarre forms which would otherwise have succumbed in the struggle for existence, at the same time renders island species especially liable to extermination by introduced forms. An ant introduced into Hawaii has destroyed the endemic forms in extensive forest areas. The introduction of cats and dogs, which have run wild, has resulted in the extermination of the native fauna of several islands—though very occasionally the animals have been able to change their habits in time, like the tooth-billed pigeon of Samoa, which has recently adopted an arboreal life. Lord Howe island was made a bird reservation in 1879, but in 1918 a steamer was wrecked there and its rats swam ashore and multiplied; within three or four years most of the native fauna had been exterminated. Until recent years native birds were plentiful in Viti Levu, the largest island of Fiji. Then minahs and bulbuls were introduced from India, and also the mongoose, the last for the purpose of killing the rats in the plantations. The result has been that these adaptable immigrants, especially the

mongoose, have driven all native birds and most of the other small native fauna into the remoter recesses of the island. Native birds are rarely seen, while minahs and bulbuls are abundant, even in Suva.

Many kinds of animals have been introduced to the island by man, either deliberately or unintentionally, first by the native peoples and more recently by Europeans. The Melanesians and Polynesians coming from the west brought with them domesticated dogs and pigs, as well as many cultivated plants. With them came the rat *Rattus exulans*, the only wild mammal other than bats to be found in any of the islands east of the more westerly Solomon islands. This small rat has evidently been carried about in canoes, and is found n nearly all parts of Oceania, southwards to New Zealand, eastwards to Tahiti and northwards to the Hawaiian islands. Such introduced animals often spread with great rapidity in their new home. A few rabbits left on Phoenix island in 1889 seem to have been so prolific that, it is said, the island was over-run with them some years later. Deer, introduced into New Caledonia from the East Indies, multiplied so greatly that they became a pest by reason of their damage to crops; about 1930, settlers in a southern district organized a drive in which machine guns were used to kill them.

Domestic animals have often escaped and their descendants become feral. The goats of the Galápagos are much more difficult to approach than are most of the native animals which, owing to their long freedom from interference from predators or human beings, are astonishingly tame.

Pigs had run wild in many islands before Europeans arrived and wild cattle, which owe their existence to Europeans, are found in the Marquesas, and in Samoa and in Fiji. (The internal and external parasites of pigs and men are of Asiatic origin; but there are some rather surprising absences. The relative absence of tapeworms and of *Trichinella spiralis* (p. 231) from a human population intimately associated with pigs and rats is quite unexplained, and so is the absence of *Ascaris lumbricoides* in some areas, though where it has been introduced it has rapidly become common.)

Man, besides introducing species by active or passive means, also has a profound effect on the environment, sometimes enabling a species arriving by independent means to survive where it would otherwise have lacked subsistence. Many insects are restricted to one food plant, and if a suitable plant does not occur on an island they will be unable to colonize it even if they are able to reach it

repeatedly. The beautiful butterfly *Danäida archippus* is widely distributed in North and South America. It is a powerful flyer and large flocks often make extensive migrations, and it is now found in many Pacific islands including the somewhat bare atolls of the Ellice group. It reached New Zealand in 1840, Hawaii in 1845–50, the Marquesas about 1860, and Tonga and Samoa between 1860 and 1870. Its food plant is a weed introduced by shipping; but it is thought that the butterflies arrived by flight. If this is so, since it feeds only on a plant of recent introduction, this butterfly must have been flying about the Pacific ocean for countless ages without being able to colonize the islands it reached, for lack of food.

An instance of the way in which human interference can disturb the balance of nature is given by events reported on Wake island a few years ago. After the establishment of the Pan-American Airways station on one of the islets there, the large numbers of rats were found to be a great pest. Finally, resort was had to poison and the rats, ravaged by thirst, died in large numbers at the water's edge. The islets teem with hermit crabs, the common sea-shore scavengers of atolls. They devoured the rats, but in turn died, in thousands. The sea birds, which had not eaten the rats, devoured the hermit crabs, and within three weeks of the initial operations they also lay dead on the beach in large numbers, sufficient to create a most unpleasant stench. Since the scavenging hermit crabs had been practically wiped out there was now no natural means of disposal of the decaying corpses of the sea birds. The upshot was that rat-poisoning was cancelled, and as soon as it was thought that the effects of the poison had passed, quantities of hermit crabs were secured from another islet and released in the hope that the faunal balance would once more be restored.

Distribution of Pacific Land Fauna (Birds)

An analysis of the distribution of the families of land birds in the Pacific islands will serve to illustrate the pattern of the distribution of the land fauna in general, and it will be seen how well the distribution of the land birds agrees with that of the insects as indicated by Zimmermann's map (Figs. 69 and 70.) The Hawaiian islands are so isolated and have consequently such a special fauna that it will be well to deal with them separately; the Galápagos and Juan Fernández also come in quite a separate category. Almost the entire land fauna of the rest of the Pacific area has migrated from the west and is either Australian, Papuan or Asiatic in origin. Nearly

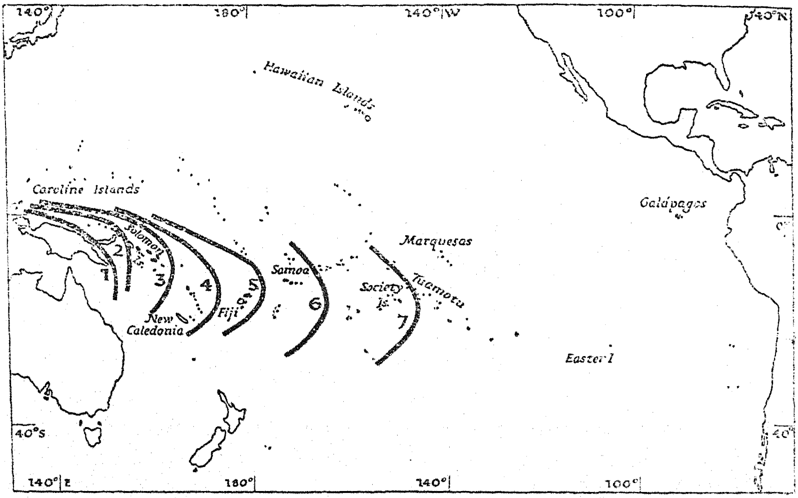


Fig. 69. Eastern limits of ranges of New Guinea land birds

1, Pelicans, storks, ibises, orioles, nuthatches, birds of paradise; 2, cassowaries, bee-eaters, nightjars; 3, true owls, water kingfishers, pygmy parrots, cockatoos, pipits, sunbirds, hornbills; 4, crows; 5, hawks, babbling thrushes, brush turkeys, thick-knees; 6, honey-eaters, thrushes, weaver-birds, white-eyes, cuckoo-shrikes; 7, barn owls, starlings, shrikes; 8 (no eastern limit), plovers, sandpipers, snipes, rails, cuckoos, wood kingfishers, lories, turtle doves, herons, pigeons, fruit pigeons, swifts, flycatchers. Based on various sources.

all the birds belong to families with representatives in New Guinea and it will be convenient to start with the New Guinea families.

(1) The pelican, stork, ibis, oriole, nuthatch, and bird-of-paradise families are not found in other parts of the Pacific area, though all but the birds of paradise have a wide geographic distribution elsewhere. The birds of paradise are confined to New Guinea and North Australia and a few nearby islands. (2) Cassowaries, bee-eaters and nightjars have representatives also in the Bismarck archipelago. (3) True owls, water kingfishers, king crows, pygmy parrots, cockatoos, pipits, sunbirds, and hornbills are found in New Guinea, the Bismarck archipelago and the Solomons, but not further east in the islands under consideration. Crowned pigeons and pittas also reach the Solomons. (4) The crow family is represented also in New Caledonia. (5) Hawks, babbling thrushes, brush turkeys and thick-knees extend eastwards as far as Fiji. (6) The honey-eater, thrush, weaver-bird, white-eye and cuckoo-shrike families reach as far as Samoa. (7) Barn owls, starlings and

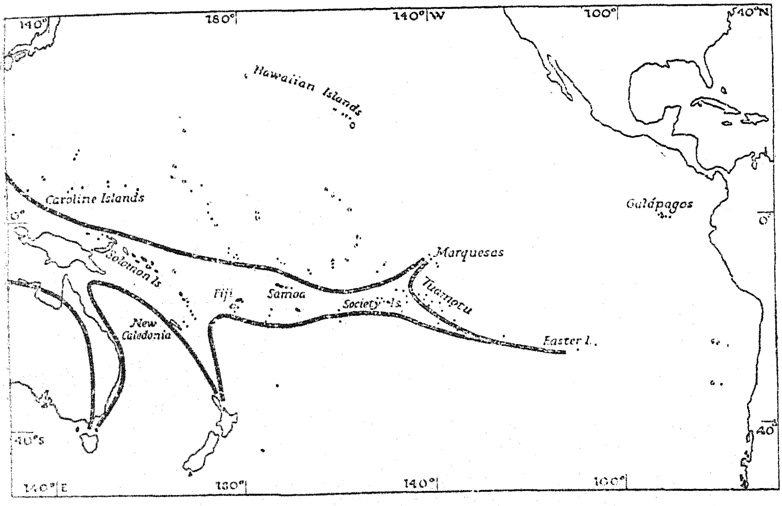


Fig. 70. Insect distribution in the south Pacific

This diagram illustrates the average normal derivations of the endemic insects of the south Pacific. Based on E. C. Zimmerman, 'Distribution and Origin of some Eastern Oceanic Insects', *American Naturalist*, vol. LXXVI, pp. 280-307 (Boston, 1942).

shrikes extend to islands to the east of Samoa, but do not reach as far as the Marquesas. (8) Finally, of the New Guinea birds, plovers, sandpipers, snipes, rails, cuckoos, wood kingfishers, lories, turtle doves, herons, pigeons, fruit pigeons, swifts and flycatchers extend over the whole of Melanesia and Polynesia, including the Marquesas.

The families so far considered all have a fairly continuous distribution and the general picture is clear that as one passes eastwards some form of animal life is left behind every time the sea between two groups of islands is crossed. The number of families with discontinuous distributions is too small to upset this picture. The swallow family is represented in New Guinea and extends eastwards as far as Fiji; then there is a wide gap until it reappears in the Society islands. The warblers are found in New Guinea, the Bismarck archipelago and the Solomons, and there are a number of endemic species in the Austral islands, the Society islands and in the Marquesas; but they are absent from the whole of intervening western Polynesia. Bustard quails, grebes and frog-mouths are found in New Caledonia; but not in the New Hebrides or the Solomons. Honey-peckers occur in New Guinea and the Bismarck archipelago and also in the Tuamoto archipelago. The flightless

kagu (French, *kagou*) of New Caledonia, and the tooth-billed pigeon (*Didunculus*) of Samoa have been given families to themselves which are not represented anywhere else in the world outside these two respective places. The islands named in the above lists form a fairly continuous series from west to east and all the groups contain high volcanic islands with forests. The Gilberts, the Phoenix and the Ellice islands and also the Marianas, Carolines and Marshalls to the north are all groups of low coral atolls with little vegetation and a much more scanty fauna. However, many of the families of birds found to the east of Fiji also have representatives in these atoll groups.

As a result of their extremely isolated position the fauna of the Hawaiian islands does not show a close relationship with any other fauna. Nearly all the species and most of the genera are endemic. There is one family of birds, the brightly coloured, beautiful Drepanididae, which is found in the Hawaiian forests and which occurs nowhere else in the world. Of the other Hawaiian families of land birds the honey-eaters and flycatchers have representatives in the west but are unknown in the Americas. The finches are found all over the world except in the East Indies east of Borneo, New Guinea, Australia or Polynesia. The plovers, sandpipers, snipes, rails, crows, herons, hawks and owls are found both east and west of the Pacific.

The birds of the Galápagos, while largely endemic, are clearly of ultimate Central and South American origin, and include finches, humming-birds, honey-creepers, flamingoes and mocking birds. The fauna of Juan Fernández shows similar relationships to South America.

The analysis which has been given of the distribution of the birds by families brings out the general trends very well; but it obscures one important feature, that is, the very limited range of most of the species concerned. A few species are very widespread; but most species are restricted to a small group of islands, often to a single island. Nearly every island in the Pacific possesses some species of animal which is restricted to it and cannot be found anywhere else. Such species are very easily exterminated. Cutting down a forest on an island, for example, may mean the loss of dozens or hundreds of species of plants, birds, insects, snails and other animals which occurred there.

The sea birds of the Pacific are not of particular interest from the geographical point of view. Terns, petrels, ducks, frigate birds,

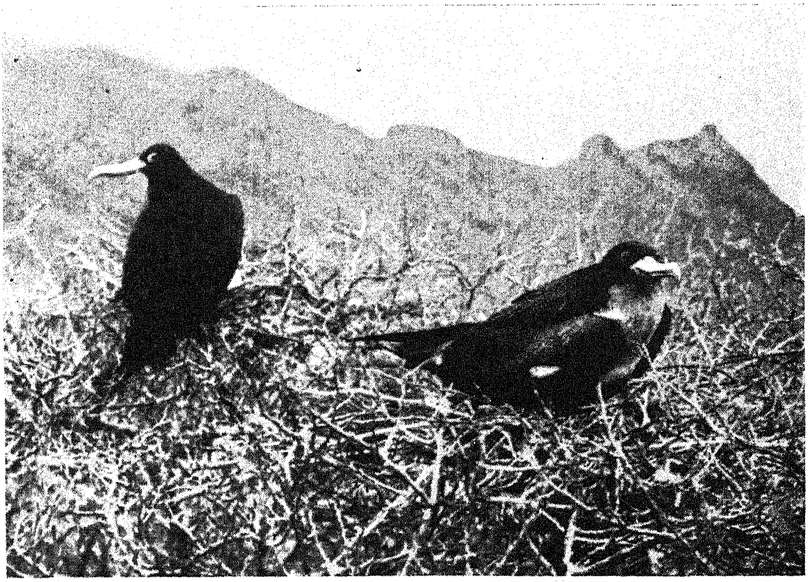


Plate 59. Great frigate birds nesting, Hatutu, Marquesas

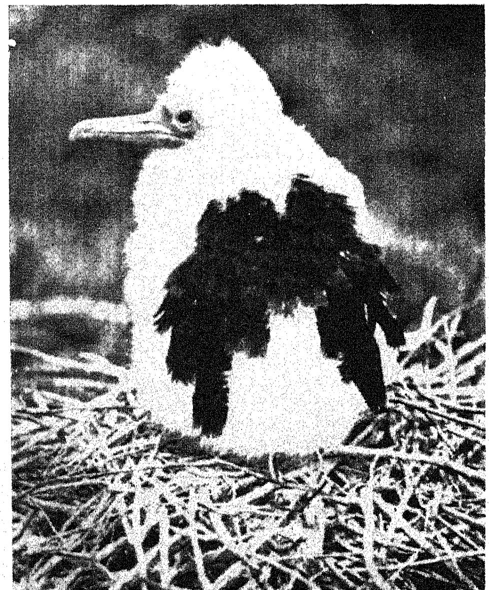


Plate 60. Young frigate bird
The brown adult plumage is beginning to

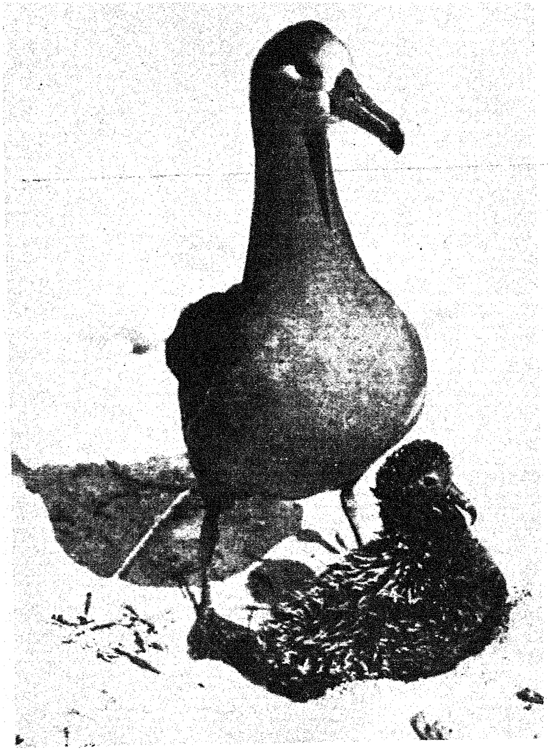


Plate 61. Black-footed albatross and young, Laysan, Hawaiian islands

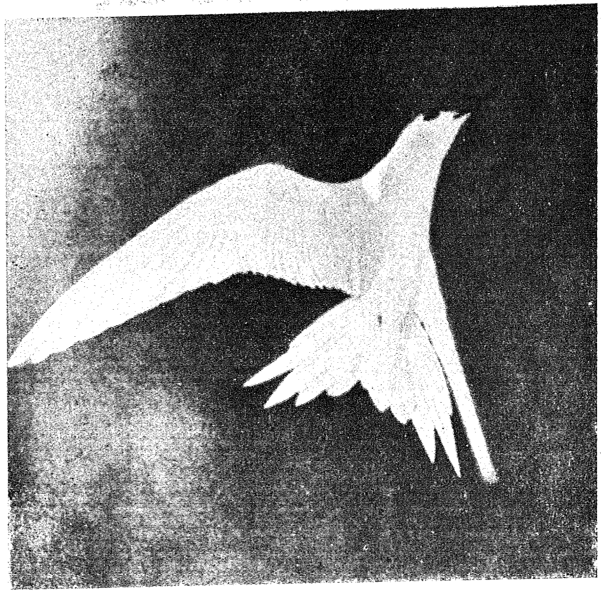


Plate 62. Love tern, Wake island

These birds are snow-white, with jet black bill and eyes. The under surfaces of the wings reflect blue and green colours from the water.

boobies and tropic birds are widespread. Frigate birds (Plate 59) are the most completely aerial of sea birds; they never alight on the water or on level land but fly in the air all day and rest in trees or on a slope at night. Their food consists of fish and other creatures picked up from the surface of the water in flight. They also chase other sea birds and force them to disgorge their food for them. Cormorants are strangely absent from tropical Polynesia but are found in some parts of Melanesia, and there is a flightless species in the Galápagos. The cold Peru (Humboldt) current flows northwards off the South American coast, and although they are right on the equator the Galápagos have a species of penguin (*Spheniscus mendiculus*). Elsewhere in the Pacific, and in the southern oceans generally, penguins (except for the Humboldt penguin, which breeds at 6° S on the coast of Peru, and the blue penguin, which breeds as far north as Moreton bay in Queensland) are limited to higher latitudes. They are found on the shores of Antarctica and in the islands of the south-west Pacific, including the Kermadecs. There are three species of albatross (Plate 61) in the area, two of which breed in the Hawaiian and other Pacific islands, and the third in the Galápagos.

Life in the Ocean

All the life in the sea, as on land, is ultimately dependent on the sun for its energy. Plants use this energy to build up the organic substances required in their structure from carbon dioxide and certain essential minerals dissolved in the water. Animals build up their bodies by feeding on plants or other animals, or on the remains of plants or animals. The depth to which light penetrates depends on the turbidity of the water, but even in clear open waters there is insufficient light to support much plant life below about 100 fathoms. The only plants found below this level must be dead, and all the animals are either scavengers or carnivores. Thus the amount of light in the different depths of the sea primarily determines the development of plant life and thus influences the animal life secondarily. It has also an influence on the coloration of animals and on their vision.

Traces of light can be detected by photographic means to a depth of over 500 fathoms in the open subtropical ocean. The more nearly the poles are approached, the shallower is the depth at which plants get enough light for growth, so the plants and the animals dependent on them for food are concentrated near the surface.

The temperature relations of the water are of great importance to the understanding of marine zoogeography. The temperature of the sea varies with location and also with the seasons. The polar and tropical seas have relatively uniform temperatures throughout the year. The annual range of surface temperature is less than 7° F. on almost three-quarters of the ocean surface, and on one-third of this, especially in the tropics, it is less than 3° F. The greatest variations appear in localities where warm and cold currents meet and predominate by turns. As the temperature of the surface of the water is raised by the sun's heat in the summer months the water decreases in density; as a result it stays at the surface, and there is a gradual decrease in temperature with depth. Over 80% of the ocean floor is more than a mile below the surface and has a temperature of 37° F. or a little less. The radiant heat of the sun does not reach deep into the water and the effective distribution of the heat in the depths is accomplished by water movements. The colder, and hence denser, waters of the polar seas sink and flow slowly along the ocean floor towards the equator and are replaced by warmer water in surface currents. On lee coasts within the influence of the trade winds, the warm surface water is continually blown away and driven against the windward coasts. This is compensated for by an upward flow of cold water. The lower waters are often separated from the surface layers by a very definite boundary, or discontinuity layer; there may be several strata of water of different origins and different densities one above the other. There is usually a sudden drop in temperature as the discontinuity layer, or thermocline, is crossed from an upper to a lower layer. These discontinuity layers impede the mixing of the waters and there is a marked difference in the physical properties and the chemical and biological content of two adjacent strata. A discontinuity level is found in all warm seas and usually lies between 25 and 75 fathoms.

The chemical content of sea water is remarkably constant as a slow but complete mixing of all layers takes place. The slight differences in composition which do occur are, however, of great importance biologically. Phosphates and nitrates are minerals essential for plant life, and they are present in sea water in such very small amounts that the growth of plant life and thus also of animal life of a given part of the sea is limited by their concentration. Plants can only make use of them where there is light, and so the phosphates and nitrates are rapidly used up in surface waters but accumulate lower down. The plants have to secure them from an

extremely dilute solution and this necessitates that they be of small size in order to have a high ratio between area of surface and bulk. In contrast to the plants on land, the marine plants which form the basis of the food chain, even for fishes and whales, consist of microscopic diatoms and other even smaller plants. The loss of these minerals from the surface waters is increased as the bodies of many dead organisms which have fed on the plants sink below the plant-inhabited layers. Here the nitrogen and phosphate content of the water cannot be used and so the concentration increases with depth. The fertilization of the lighted upper waters by nitrogenous compounds occurs largely through the upwelling of deep water and the inflow of fresh water from the land.

In shallow coastal seas the tides and storms are able to keep the waters mixed, and in temperate and cold latitudes there is a periodical mixing of the waters in consequence of the cooling of the surface water in the winter. By this means nitrogenous water is brought up from about 70 fathoms in temperate waters and from 400 or more fathoms in Arctic and Antarctic waters. A great outburst of diatom growth follows in the spring when the light increases. On coasts where continued off-shore winds carry away the surface waters a compensating current rises from the depths, carrying with it nitrates and phosphates. No oceanic waters swarm so with life as the upward streams of deep water when they reach the surface in tropical latitudes. The coast of Chile with its cold upward currents is especially notable for the wealth of its marine life, and the nitrates of the guano deposits have come from this source through a complex series of food chains of the type: diatom, copepod, fish, bird. Vertical mixing also occurs where a warm current passes a cold one, and again a rich fauna results.

In tropical oceans generally, however, there is comparatively little life as there is very little mixing of the waters. The scarcity of life in tropical waters may however be partly illusory. The temperature is high and the biological processes are greatly speeded up so that a life history may only take a few days instead of several weeks. Another contributory cause of the poverty of life in the open south-eastern Pacific is the fact that compared with other oceans the Pacific has very few long rivers flowing into it. Nearly three-quarters of the extent of the entire Pacific ocean is 2,000 fathoms or more deep, and there are no continental shelves on the west coasts of the Americas.

Oxygen is present in sufficient quantities for life at all depths in

the open oceans. It is naturally most abundant near the surface, especially in the lighted zone where it is given off by the planktonic plants. Towards the bottom of this zone plants absorb as much as they give off and at a depth of about 250 fathoms there begins to be some deficiency. At greater depths, however, there is less food supply and so there are fewer animals to use up the oxygen. As it is being constantly brought in from high latitudes the great ocean depths have an oxygen content only a little below normal. If it were not for this circulation the oxygen would soon be all used up. In some parts of enclosed seas like the Mediterranean and Baltic there is no such bottom current and carbon dioxide accumulates and there is lack of oxygen. In deep inland seas and in some isolated bays and harbours where there is a rich surface fauna and stagnation in the bottom waters, the lack of oxygen becomes so great at the bottom that the hydrogen sulphide produced by the decomposition of animal matter is not oxidized and accumulates. In extreme cases, such as at the bottom of the Black sea, all life becomes impossible.

Pelagic Animals

Pelagic animals may be grouped according to their ability to swim freely (that is, independently of the oceanic currents) or according to their dependence on the latter. Those whose independent movements are insignificant in comparison with the movements of the water belong to the plankton. All animals less than half an inch long which are suspended in the water, either at the surface or in deeper layers, come under this category and so do many of the larger forms, particularly the jellyfish. Nearly every group of invertebrate animals has representatives in the plankton. A great many bottom-living and sedentary animals are planktonic during the early stages of their life history; worms, starfish, oysters, crabs (including land crabs), corals and many fishes have free-swimming larvae which drift in the surface waters. While the total number of individuals in a given volume of water is comparatively small in the tropics, there is a much greater variety and there are many more species than in higher latitudes.

Living matter is a little heavier than water and so planktonic animals have special adaptations to prevent them from sinking. As far as possible the specific gravity is reduced, and shells are very thin or absent. Jellyfish, pteropods, pelagic bristle-worms, squids, and some feebly swimming fish all take up large quantities of water so that their tissues are light, transparent, and jellylike (Fig. 71).

Flotation is aided in many of the animals, from protozoa to basking sharks, by accumulations of fats and oils. Gas is present in the floats of the Portuguese Man-o'-War and the By-the-Wind-Sailor, and also in the air sac of bony fishes and the lungs of sea snakes,

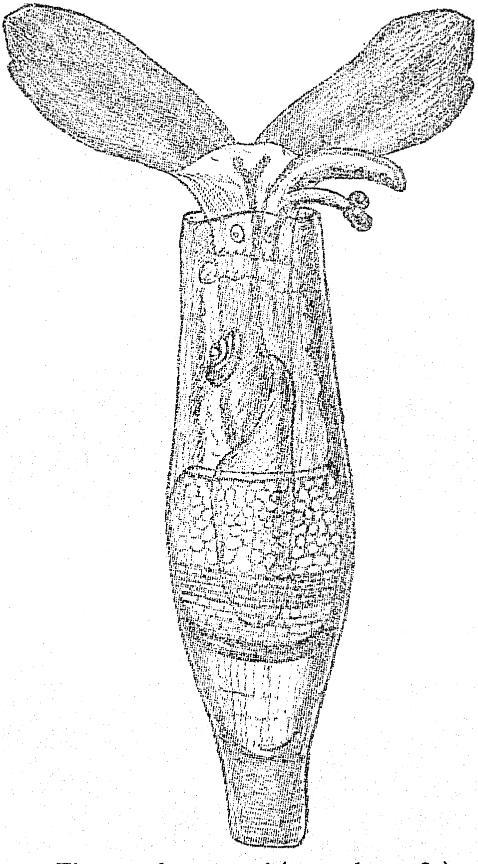


Fig. 71. A pteropod (or sea butterfly)

An example of a mollusc showing a number of modifications of structure for pelagic life. The body is perfectly transparent and gelatinous ; the shell is very light and paper-like ; and the 'foot' is modified into a pair of flapping 'wings'. About three-quarter natural size. Drawn by J. P. Harding.

turtles, seals and whales. A large number of small planktonic organisms of different kinds retard the rate at which they sink through the water by having long spines or feathery processes, or by extreme flattening so that the frictional resistance to sinking is

greatly increased. Several examples are shown in Fig. 72. Many pelagic animals keep up in the water by active swimming. Feeble swimmers like jellyfish and pteropods direct most of the energy of swimming to opposing gravitational pull, and there is very little movement in a horizontal direction. Better swimmers adopt more streamlined shapes, and suspensory processes are placed in the plane of motion (as in *Calocalanus*) or dispensed with altogether. The fish of the mackerel group, which includes the bonitos and albacores of tropical seas, are all extremely vigorous swimmers and streamlining is carried to perfection; even the body fins fold into groves.

Flying fish (Plates 63–4) are found in the surface waters of all warm seas, mostly in the open ocean far from land. They form the principal food of many large ocean fishes, and it is mainly in order to escape from their enemies that they leap from the water and then glide for a distance of two or three hundred yards. There are about 50 species of flying fish and they may be divided into two main types, the four-winged and the two-winged forms. The former have the pelvic as well as the pectoral fins enlarged into 'wings' and are the better fliers. The fish swims rapidly upwards with both pairs of wings folded to the body, and breaks the surface with the front of the body and spreads the front wings. The fish then 'taxis' along the surface of the water, propelling itself forward by powerful lateral thrusts of its tail, the lower lobe remaining in the water. The violent movements of the tail cause the whole body and wings to vibrate so that the latter appear to flap, though they are in fact held rigidly. When a speed of 35 m.p.h. or more has been attained the fish becomes airborne; the pelvic fins are raised, the tail is lifted from the water and the fish glides through the air with both pairs of wings held out stiffly. At the end of the glide it either dives gracefully into the water or gets up speed for a second flight by lashing the water again with its tail. The two-winged forms glide through the air in much the same way; but they dart directly into the air from the sea and return with a splash at the end.

Most planktonic organisms make vertical diurnal migrations and move upwards at night. The surface water of the oceans become much richer in plankton at night for this reason.

The minute plants and the small animals which feed on them directly, including particularly the copepod crustacea, which comprise 90% of the fauna, occur in enormous numbers. A great many of the pelagic animals of all kinds and sizes, ranging from small crustacea less than a quarter of an inch long to the largest

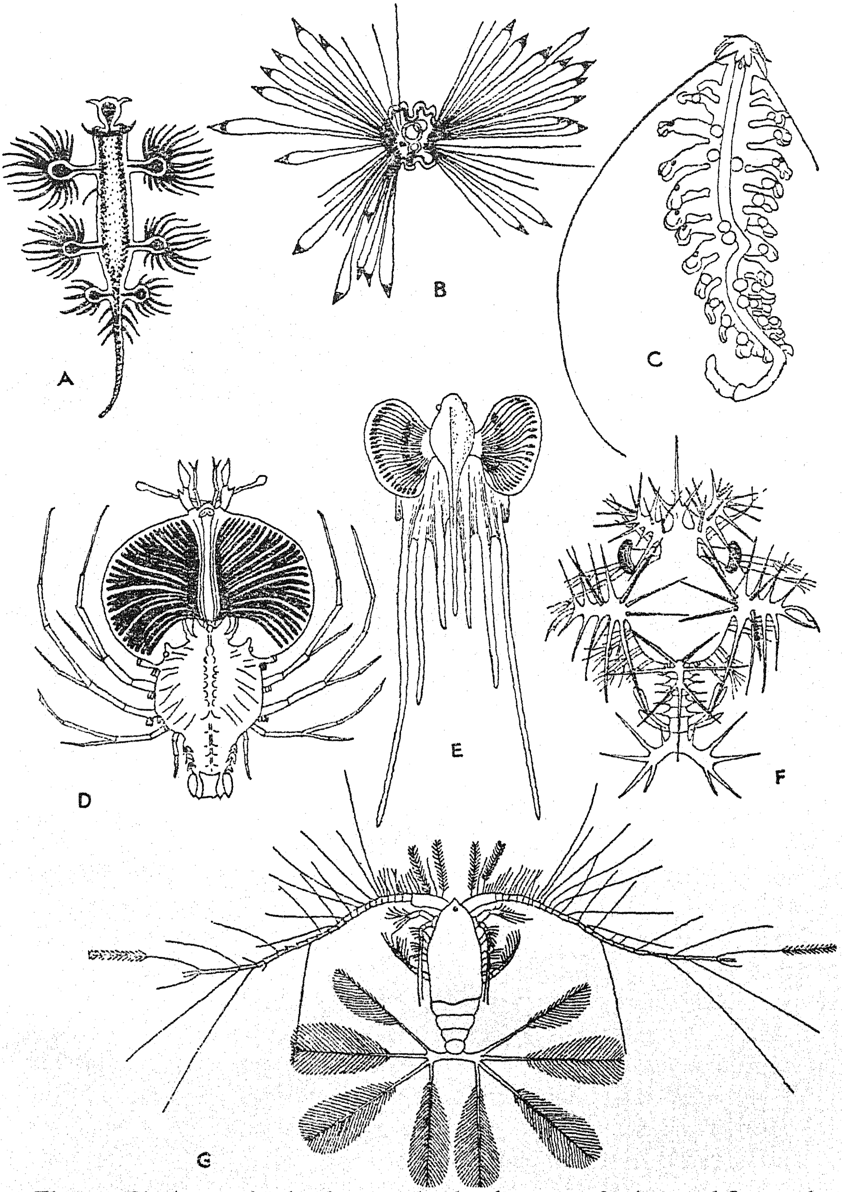


Fig. 72. Plankton animals, showing the development of spines and flattened process to aid flotation in a number of different types of animal

A, *Glaucus*, a pelagic sea slug; B, *Mitraria*, the larva of a bristle-worm; C, *Tomopteris*, a bristle-worm pelagic when adult; D, *Phyllosoma*, the larval form of the crustacean *Palinurus*; E, *Lophius*, the pelagic larva of a bottom-living angler fish; F, *Sergestes*, a crustacean larva; G, *Calocalanus*,

whales, have developed sieve-like strainers for securing their food in the form of enormous numbers of organisms, small compared with themselves. Copepods have a complicated arrangement of moving mouth-parts with bristles. The structure and movement of the parts are so arranged that a current of water flows through a mesh of fine bristles, leaving the food on them to be raked into the mouth. Plankton-eating fish, including large forms like basking sharks, have gill rakers which sieve out the food from the water before it flows over the gills from the mouth. Over 60,000 small copepods captured in this way have been found in the stomach of a single herring. The whales have great plates of whalebone from which long fringes hanging down into the mouth sieve out the food in the same sort of way. These screens are very effective; some are capable of capturing planktonic organisms which are too minute for the finest silk nets and which remained undiscovered until the food collected by the filter plates of appendicularians was examined.

Most pelagic animals, whether active swimmers or not, are very widespread in the oceans; but the distribution is not uniform. The composition of the plankton varies with time as well as with locality. Usually there are a great number of different species; but at a given time and place one species may flourish and overwhelmingly predominate. This is especially the case in shallow seas. The plankton of the open Pacific is not so liable to sudden changes and most of the fauna is made up of animals independent of the bottom throughout their life history. Near land, or where the sea is shallow, additional species which are dependent on the sea bottom for part of their life will be included. The distribution of the whales is dominated by the distribution of their food supply. The whalebone whales like the blue whale (Fig. 73) are at home in the Arctic and Antarctic seas where there is such an abundant plankton; they migrate from the polar seas in the winter to breed. The hump-backed whale is found in Pacific coastal waters feeding on plankton and small fishes. In the open warm seas the plankton is comparatively rare and the richest life is at a lower level where there are large numbers of large crustacea and squids. These are found in the stomachs of the sperm whale, which is found in these warm waters and is noted for the great depths to which it can dive.

Animals of the Sea Floor

The environmental conditions of the floor of shallow waters are very varied and the fauna is very rich; perhaps the most important of

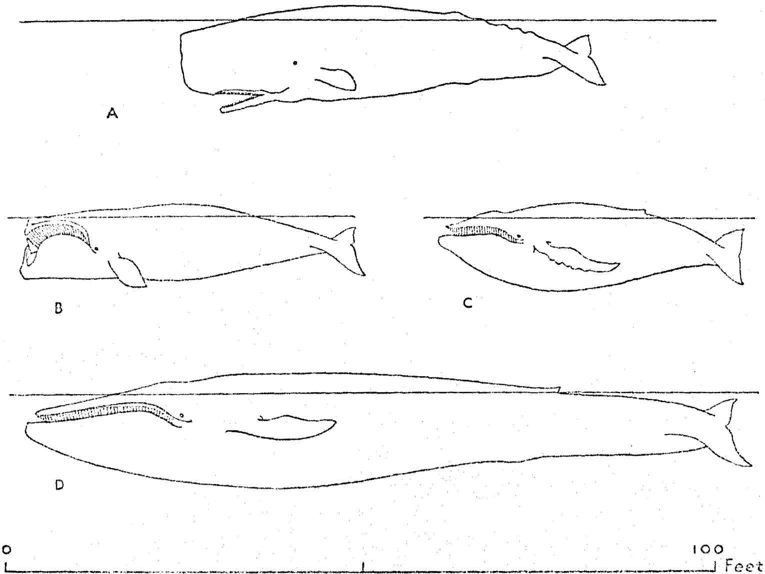


Fig. 73. Whales found in the Pacific ocean

A, sperm; B, black right; C, humpback; D, blue. Based on various sources.

the many factors concerned in determining the nature of the animal community is the type of substratum. The crannies found along rocks provide shelter for a great many different kinds of animals and the rocks provide a substratum for sedentary forms; in the Pacific, coral reefs provide this type of environment in shallow waters and these will be described later.

Burrowing animals of all sorts are characteristic of sandy bottoms. Many, particularly the worm-like forms, ingest the sand and digest the organic debris it contains as it passes through the body. These forms need specially well developed gills with an extensive surface well supplied with blood to take in the scanty supply of oxygen in their surroundings. Other forms remain more or less stationary in their burrows and have some arrangement which causes a current of water to flow through a sieve and over the gills bringing both food in suspension and oxygen in solution. The numerous species of sand-living bivalve molluscs have a pair of hollow siphons protruding above the surface of the sand, one leading to and one away from the gill chamber. The gills are in the form of very fine nets with the meshes covered with microscopic cilia which lash the water through

the meshes and also direct streams of mucus, in which the microscopic food organisms became entangled, to the mouth. Some of the burrowing crabs form a tube of their antennae which leads down from just above the surface of the sand to the mouth and gills; other crabs have other arrangements for the same purpose. Sea-urchins and tube-dwelling worms have various devices which again bring a current of water to them while they lie hidden in the sand. There are also many predatory animals in the sand and especially creeping over its surface. Starfishes, octopuses, univalve molluscs, crustacea, especially hermit crabs, and also bottom-living fishes, flat fishes, skates, rays and angler fishes are found here.

Mud dwellers have a mode of life on the whole similar to that of sand dwellers, but there are fewer of them in a given area as the supply of oxygen is more limited. In the main, mud-living forms are more delicately built than sand dwellers, and have thinner shells and a weaker musculature.

Animals of Abyssal Depths

The fauna of the abyssal depths is quite unlike that of the relatively shallow waters which lie outside the geologist's Pacific basin (p. 14). The conditions are so different, and there can be very little interchange between the populations of the two zones across the slope which connects them. Conditions are more unchanging in the abyss than anywhere on the earth's surface. There is no difference between day and night or summer and winter. The waters are absolutely still and silent and uniformly cold and dark. The pressure is very great, from two to five tons per square inch; but as the pressure inside the animals is as high as it is outside they come to no harm. As a result of the complete absence of water movement, other than the very slow circulation described above, most of the animals are very gracefully and delicately built; even the pelagic fish have delicate, fragile skeletons and feeble muscles at these depths.

Most of the bottom is uniformly covered with a deep layer of soft ooze of the consistency of summer butter, and animals living on it require some means of support. Some of the sedentary animals, sea lilies and the like, have root-like growths and long stalks. The sea urchins which creep over the ooze are often flattened so as to spread their weight over a wide surface, and many of the crustacea have very long slender limbs with the terminal joints expanded by a fan of bristles to increase the supporting surface.

No plant material is available for food so the animals are all either

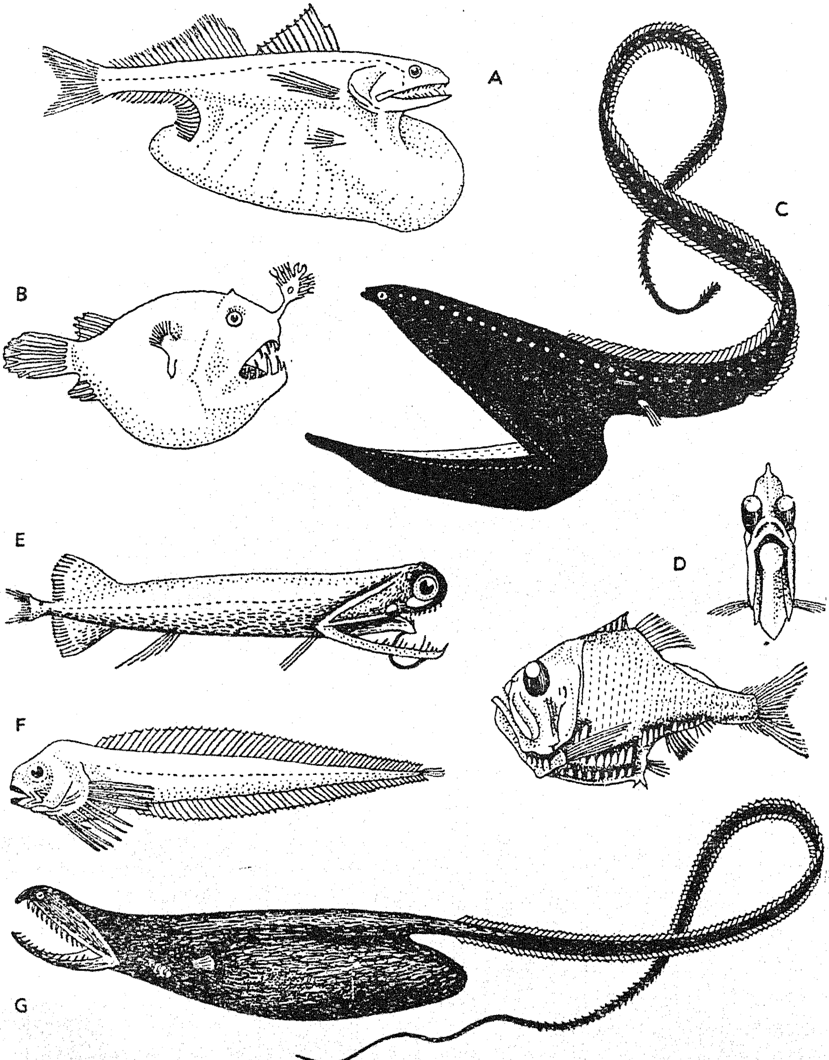


Fig. 74. Various forms of deep-sea fish

The predatory nature of these fish is shown by the large mouths furnished with long recurved teeth, and by the distensible stomachs which enable the fish to eat others as large as or larger than themselves. Rows of luminous organs are shown in C and D. The angler-fish (B) has a luminous lure and D and E have enormous eyes. The fishes are as follows: A, *Chiasmodon*, 'great swallower'; B, *Borophiyne*; C, *Eurypharynx*, 'gulper'; D, *Aegyrepelecus*, 'hatchet-fish'; E, *Malacosteus*, 'wide mouth'; F, *Paraliparis*; G, *Saccopharynx*, 'gulper'. Based on J. R. Norman, *A History of Fishes*,

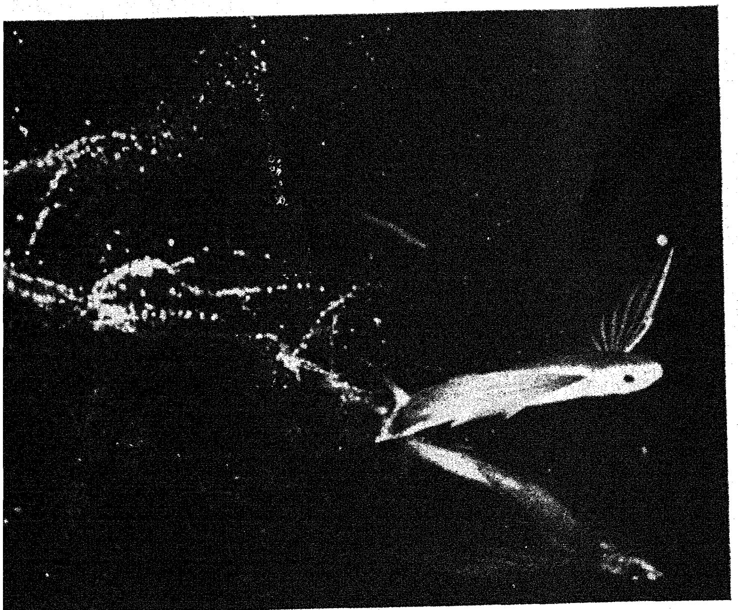
scavengers or predators. Food in the form of the remains of animals and plants from higher levels falls gently to the depths. It falls very slowly and most of the bodies of animals which die near the surface are probably devoured long before they reach the depths of the ocean. So, under equal conditions, the deeper the ocean the less the food supply which reaches the bottom. This must be one of the reasons why animals are so sparsely distributed here, and perhaps is why deep-sea animals are generally much smaller than their relatives at the surface. Most of the fishes are only an inch or two long.

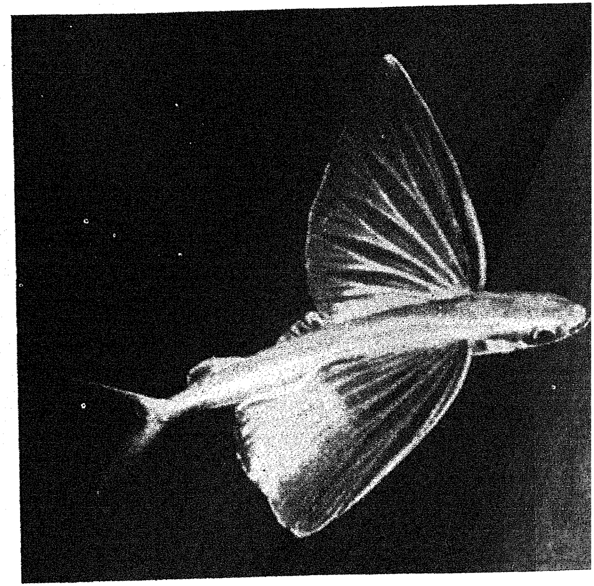
On the bottom are many detritus feeders living on the remains of animals from all levels above. In general these are similar to detritus and mud feeders of shallow waters. Sea cucumbers of many colours plough their way through the ooze, swallowing it as they go and extracting what nourishment they can. Many of the predatory fish have very wide mouths furnished with long recurved teeth and distensible stomachs (Fig. 74). They rarely find a meal; but when they do it may be a very large one. One deep-sea pelagic fish was captured and brought to the surface with a second fish of its own species larger than itself in its stomach.

Colour and Phosphorescence

There is a close correlation between the colours of marine animals and the depth at which they are found. The majority of the young fish and other animals in the upper waters are colourless and glassily transparent. Below about 300 fathoms the fishes are nearly all black and the crustacea red. As red rays are rapidly absorbed by sea water, there is no red light at this depth and to other animals here the red crustacea will appear as black as the black fish. The dark coloured fish are found nearer the surface in high latitudes and also at night. Animals living among rocks and weeds or on sand or gravel, in shallow lighted water, are often brightly coloured with stripes and spots and other patterns which match their surroundings. Many of them are able to change their colour according to the background against which they are seen. Poisonous or distasteful animals may have conspicuous colouring to warn predators of their obnoxious nature. The brilliant colours of animals associated with coral reefs will be discussed later. Nearly all deep water animals are of a uniform colour, black, red, grey or white.

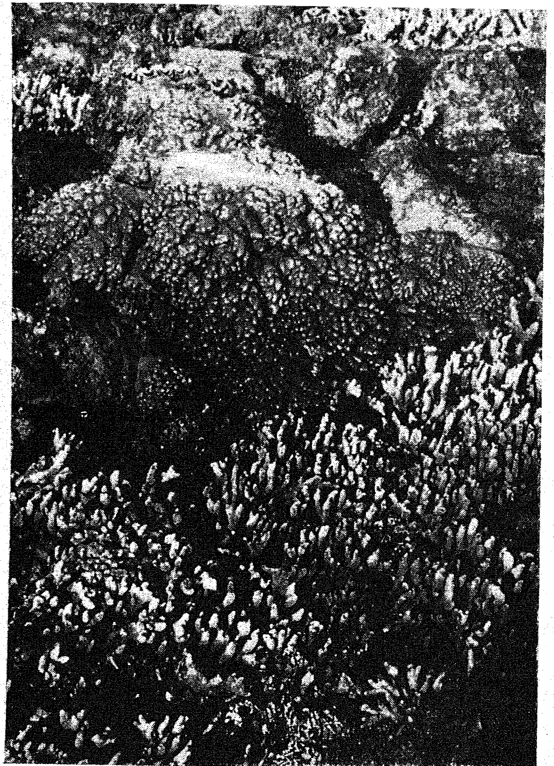
Many marine animals are luminous. The phosphorescence of the sea on a dark still night is the result of the activities of a great

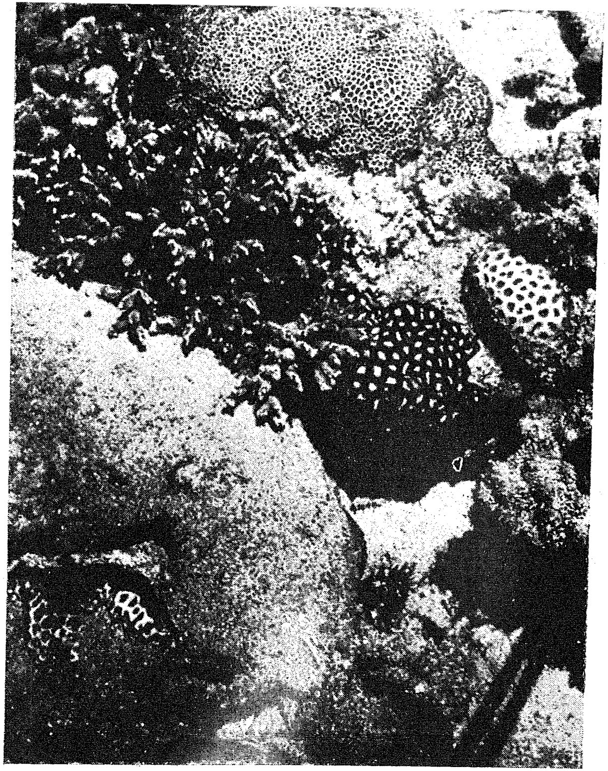




Plates 63, 64. Flying fish

photographs show (left) the fish taking off, leaving a wake of spray and bubbles, and (right) the fish in mid-air with 'wings'





Plates 65, 66. Sections of coral reef.

Plate 65 (left) shows the coral left exposed by the receding tide; branching *Montipora* can be seen in the foreground, with a fully contracted soft coral behind. Plate 66 (right) is a view looking down into a moat where the coral remains covered with a constant level of water at low tide. Branching *Montipora* and massive colonies of *Favia* can be seen in the coral sand between. A large boulder of dead coral in the left-hand bottom corner is being recolonized by a *Favia* in the centre.

many different kinds of animals. *Noctiluca*, a protozoon, is the one most often named; but many of the small planktonic animals contribute. The lower forms may give off a luminous secretion from the general body surface. Some of the copepods have special glands which discharge a luminous substance into the water so that little clouds of phosphorescence are formed. Many of the small jellyfish carry a girdle of little lights which flash in unison. Light-producing organs are developed to their fullest extent in larger animals living in deeper water. Complex organs arranged in rows along the sides and on the head have been evolved independently in such different groups of animals as decapod crustacea, squids and fishes. They are like little searchlights and are complete with reflector behind and lens in front, and sometimes a coloured filter is incorporated so that the light, instead of being white, is blue, green or red. These organs are under direct nervous control and can be switched on and off at will. Light organs are rarely developed in animals confined to coastal or boreal waters; they are most fully developed in animals from depths near to the limit of light penetration, and gradually decrease in size at greater depths. In very deep water and on the bottom these special light-producing organs are rare, though many of the bottom-living worms and other invertebrates secrete a general luminescence. The eyes of pelagic fish and crustacea also tend to become small and imperfect in depths below 250 fathoms and below a certain depth most forms are blind. Most bottom-living fishes, on the other hand, have very large eyes, even in the greatest depths of the ocean. Presumably there is sufficient general luminescence produced by bottom-living invertebrates for those eyes to be of use. Probably the pelagic deep-sea fish are blind because the population is too sparsely distributed for there to be enough light from what luminous organs they may possess.

Octopuses are bottom-living animals and do not develop light organs like their pelagic relatives the squids; but their eyes are often large. The light is produced by all these different animals by the secretion of luciferin and its subsequent oxidation in the presence of luciferaze. It is an extraordinarily efficient process as the light is cold and none of the energy is lost as heat.

The function of luminous organs is very little understood; in some cases where the animal remains buried in mud and the light can never show, the luminescence is probably only a by-product of metabolism and may serve no useful purpose. Animals living in burrows, like the rock-boring piddock and some of the tube-worms,

are also hidden from view; but it is possible that the light tends to attract into the burrows minute animals on which they feed. In gregarious swimming animals luminous organs may help individuals of the same species to recognise each other, and one member may be able to see its prey against the background of light produced by its fellows. No doubt they often serve to attract the sexes in the breeding season. The natives of some islands use the luminous organs of fish as bait with a success which suggests that their rightful owners may also find them useful for attracting their prey. Some of the deep-sea angler fishes do in fact dangle a luminous lure, on the end of a long tentacle, in front of their gin-like mouths. The sudden flashing of light may dazzle or distract a pursuing enemy, or the lights may serve as a warning that their owner is harmful or unpalatable as food.

Types of Corals (Plates 65-75)

Corals belong to the group of animals known as Coelenterata which include sedentary forms like sea-anemones, hydroids and corals and free-swimming forms like jellyfish. The basic structure of all is the same and consists of a hollow double-walled body open at one end and fringed round the opening by tentacles. The tentacles are armed with tiny capsules which explode on contact with any floating or swimming organisms and some of the capsules shoot poisoned darts into the organisms while others shoot out adhesive threads. The prey is paralysed and adheres to the tentacles which are then curved round to push the prey through the mouth into the stomach, where digestion takes place by the secretion of enzymes by the inner wall, any indigestible remains being ejected by the mouth. In many forms the structure is considerably more complicated than the basic pattern described above. A great many coelenterates, both sessile and free-swimming forms, have a vegetative type of reproduction known as budding; young individuals grow out of the side of the parent in much the same way as a branch grows out of a tree. By successive budding a colony of many individuals is formed. The stomach cavities of all the individuals of a colony generally remain continuous with one another so that what is eaten by one individual helps to nourish the whole colony. In many coelenterates certain individuals of the colony specialize in feeding and others have no mouth but specialize in other functions, such as sexual reproduction.

If the simple hollow pattern were adhered to by the larger forms,

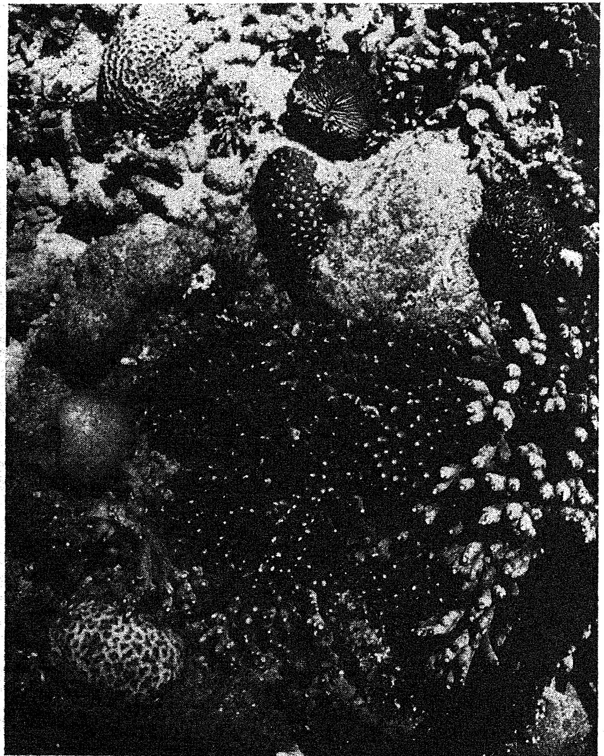


Plate 67. View downward, vertically, through the water over a reef

In addition to the branching *Montipora* and three colonies of *Favia*, there is the solitary coral (*Fungia*), top centre ; a brain coral (*Meandrina*), right centre ; and a

Plate 68. *Flabellum*, a solitary coral

In the upper example, the tentacles are expanded, so that the mouth is hidden ; in the lower, they have contracted into a groove, and the lower limit of the soft tissue lips over the cup-like skeleton below.

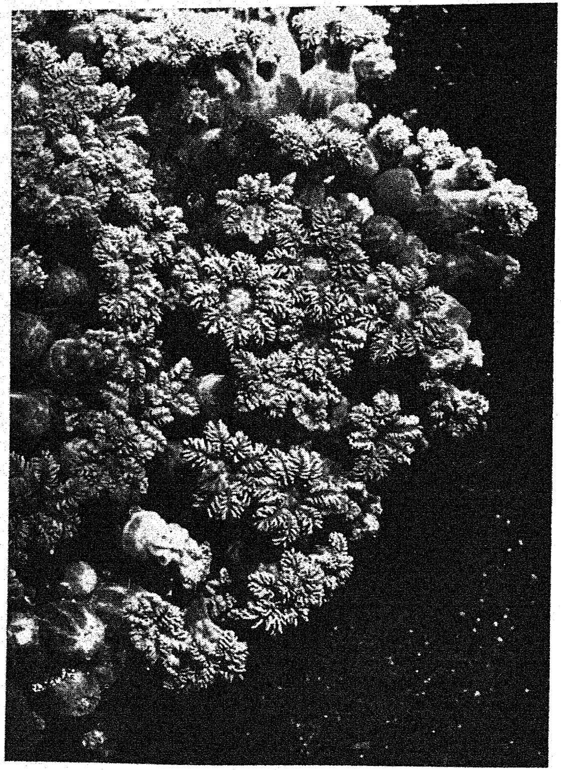


Plate 69. A colony of the Alcyonarian coral *Clavularia*
The individual polyps can be seen in all stages of expansion and contraction.

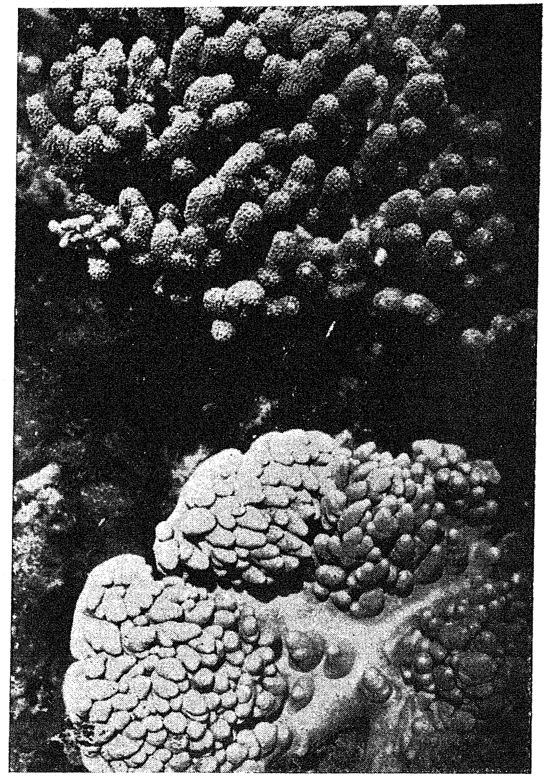


Plate 70. *Sinularia*, a soft coral
The upper colony and its polyps are fully expanded. The lower has been heavily stamped upon with rubber boots and is fully contracted.

the anemones and many corals would have too small a digestive area for their bulk, so the wall of the stomach has radially arranged partitions growing inwards and thus increasing the surface. Many coelenterates have no skeleton, but those that do often have massive skeletons of calcium carbonate ; these are known as coral.

There are three main types of coral. The most important corals are the madreporarian or ' stony ' corals ; these are mostly colonial and are of the sea-anemone type and form a thick skeleton around and below each individual. Each individual polyp sits in a pit in the skeletal mass, the floor of which is raised into sharp radially arranged ridges. The presence of these ridges, or septa, is characteristic of the stony corals. The coral may be solitary as in the case of *Fungia* (Plate 67). This is a coral common in tropical waters, and is so called because the septa look very like the gills of a mushroom, and the coral is itself very much the shape of the head of a mushroom lying with gills uppermost. When young, *Fungia* is fixed to the ground on a stalk, but later it becomes detached and drops on to the sand, where it continues to grow until it is about 6 in. across ; in spite of its weight it avoids being buried by removing any sediment which falls on it as rapidly as it is deposited. Few reef-building corals are free as is *Fungia*, or possess such large individual polyps.

Most of the reef-building corals form great colonies of many smaller individuals, all derived by budding from one original polyp, and the skeletons of all the individuals of a colony are united to form a great stony mass of coral. The final shape of the mass depends on two things, the species of coral by which it is built and the conditions under which it is growing. In some species all the polyps have equal powers of division and budding, and in these the colony may spread in a regular fashion over the substratum as an encrusting layer, or a more or less spherical mass may result. In others the growth is uneven, and lobed or branching colonies are formed. In the ' brain ' corals separation of one polyp from the next is incomplete and does not extend to the skeleton, and as the mouths and tentacles are arranged in sinuous lines the surface of the rounded mass of coral has wandering grooves resembling the convolutions of the cerebral hemispheres of the brain. The stag's-horn corals grow in branching tree-like forms ; the polyp at the apex of a branch grows most rapidly, budding off side polyps as it lengthens. When the branch has reached a certain length a side polyp some distance from the apex starts a new branch.

During the daytime most corals are inactive. The polyps expel water from their bodies and shrink down each into its pit in the skeleton, so that the latter is visible through the thin transparent living tissue, with a keyhole-shaped mouth in the middle of each pit. At night, however, a reef presents a very different appearance, as the polyps are all expanded and the body and tentacles of each elongate enormously and project far beyond the skeleton, so that the general surface of the colony may be obscured by a forest of tentacles spread out for catching food (Plates 69, 70, 75). At night the upper layers of the sea are teeming with microscopic animals and plants which sink down into deeper water by day. Corals are carnivorous and feed at night on the minute animals, paralysing them with their stinging cells and passing them to the mouth by the tentacles.

The corals so far described are of the sea-anemone type and are sometimes known as 'true' corals. All the individuals are alike, and they are the most important of the reef-building corals. Besides these there are a number of corals allied to the little hydroids, and there are also 'soft' corals (Plates 70-5). The commonest of the hydroid corals is *Millepora*, the stinging coral, which is found on coral reefs all over the world. The polyps are all united and embedded in a thick calcareous skeleton traversed by canals connecting the polyps. They are arranged in a definite pattern. The surface of the skeleton is covered with fine pores in groups, and each group has a ring of five to seven apertures with a larger one in the centre. Out of the central aperture a relatively stout and stumpy polyp emerges, this has a mouth and a stomach; and out of the smaller holes project long slender polyps without mouths but covered with little tentacles which are armed with batteries of stinging capsules, powerful enough to penetrate the human skin and cause a painful rash. The food is captured by these slender polyps and carried by them to the large central polyp where it is swallowed and digested. *Millepora* is remarkable for the great variety of the different growth forms it exhibits in different situations.

It will be remembered that the body-wall of the coral is of two layers—an inner digestive layer and an outer skin. In all the corals so far described the skeleton is secreted outside the polyp by the outer skin. In colonial forms, particularly those that are branching, this is not very obvious, as the fleshy parts of the polyps may be continuous with one another above, and cover over the skeleton secreted by their lower outer surfaces. In the Alcyonaria or 'soft' corals, however, the skeleton is formed of spicules of calcium car-

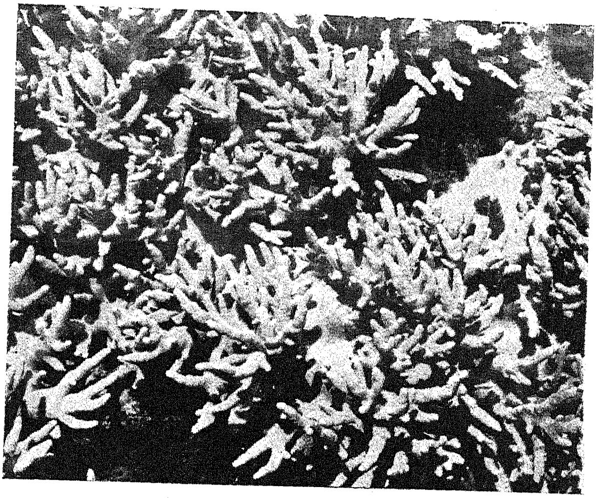


Plate 71. *Sinularia*
The colony is expanded but the polyps are contracted.

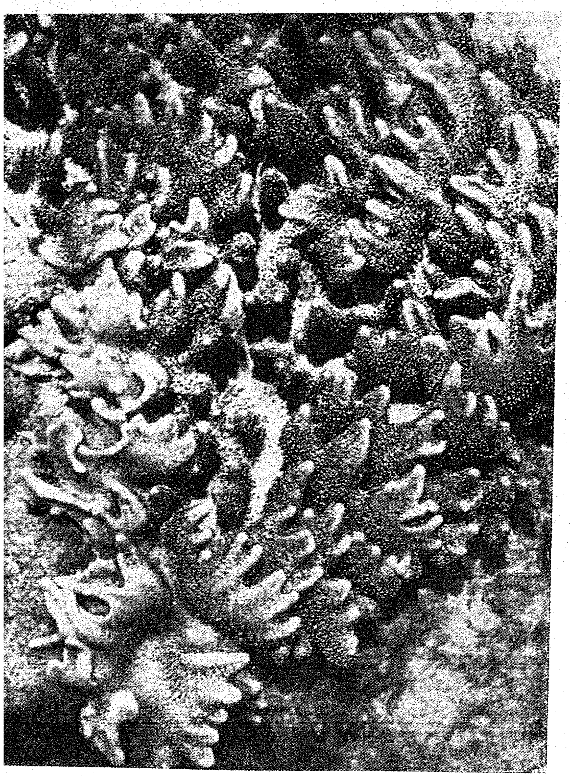


Plate 73. *Lobophytum*, a soft coral
The polyps are fully expanded on soft, flexible cocks-comb-like growths.

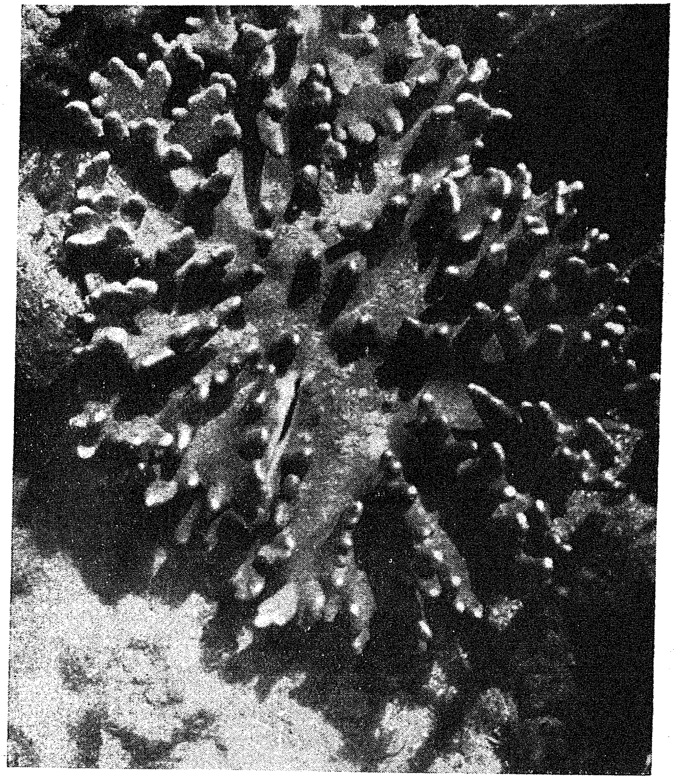


Plate 74. *Lobophytum*, contracted
The coxcombs have become reduced to smooth hard knobs, as rigid as an inflated motor-car tyre.

bonate situated inside the polyp between its outer and inner body-wall. In corals of the Dead-Man's-Fingers type the spicules remain separate and the coral grows into fleshy masses which have some powers of contraction and expansion as a whole, apart from the polyps which can sink into or extend from their pits. These colonies (Plate 66) may reach a very large size and cover several square yards. In other alcyonarians, of which the red coral of commerce is an example, the spicules are fused together to give a rigid skeleton. The red coral is not itself found on coral reefs, being confined to temperate waters, but there are others of this type which are important on reefs. The organ-pipe coral, characteristic of many exposed reef crests, has a deep red skeleton composed of a mass of parallel little tubes united together at intervals by little platforms. The living polyps with bright emerald tentacles project from the open tops of the tubes. As the colony grows older the tubes lengthen and the living coral becomes confined to the upper portions of them; the lower parts serve only to support the colony and become invaded by other animals of many kinds.

Growth of Coral Colonies

The growth form of a coral colony is very much influenced by the conditions under which it lives. This is particularly the case with branching species. Important factors in the environment concerned with the form of the coral growth are the movements of the water, the direction of the light, and the deposition of sediment. Species which grow in one plane may be so orientated that the plane of the colony is at right angles to the prevailing current, thus offering a larger surface of polyps to the food-bringing stream. In other regions, notably those of luxuriant growth in shallow water, bracket- and dish-shaped colonies presenting the maximum surface towards the light are formed. The colonies do not overlap and the bulk of the polyps are situated on the exposed sunlit surface.

The mechanical influence of the environment is considerable. It is mechanically impossible for delicate forms to exist in rough waters along the seaward edges of reefs without being broken, and if they are able to survive in these waters they must do so in compact rounded or flattened forms; and corals of the branching type growing in such places have a denser and stronger skeleton and a more compact form. Their short stumpy branches are often reduced to mere knobs. In the gently moving waters of lagoons and coral pools, species which tend to branch can do so freely, and delicately

branching forms with only lightly calcified skeletons result. In deep still water in the deeper parts of lagoons the apical polyp of *Madrepora* goes on growing undisturbed, and the polyps budded from the side remain under its dominance and do not grow into branches and have no side polyps of their own. The result is that the whole coral colony may take the form of a simple cylinder of great length and fragility, with practically no side branches.

The ability of corals to live in the gentle waters of the leeward slopes of reefs will also depend on their ability to remove sediment. Sediment rapidly kills corals if it settles on them more rapidly than it can be removed. The chief means of removal is by cilia with which the living surface is covered. The polyps of colonies living in waters where much sediment is falling tend to be relatively tall and to stand out from the general surface. Branching forms are less liable to be smothered in sediment than compact forms. When the upper surface of a coral exceeds a certain area it becomes impossible to remove all the sediment, and the polyps in the centre die. As the coral continues to grow outwards elsewhere the result is that the coral mass, at first roughly spherical in shape, becomes flattened at the top as it grows, and with further increase in size in quiet waters with much sediment, the final result may be a great shallow bowl in the hollow of which sand and other debris accumulates. Coral boulders with flat tops are also found in all regions where upward growth becomes checked by the surface of the sea and living polyps and further growth are restricted to the sides. Exceptional weather conditions, such as a thick layer of fresh water floating on the sea after torrential rains, or very bright hot weather, coinciding in either cases with a low spring tide, will cause great mortality among corals and may alter the whole facies of a reef.

The colours of a living coral reef are very striking. Not only are the corals and the calcareous algae encrusting dead coral rock of many vivid hues, but most of the other inhabitants of the shallow waters are so too. The colour of a coral is due to the living soft tissue, the limestone skeleton being usually white, and is to some extent dependent on light, for corals in deeper water generally lose their pigment. The same species of coral may be quite differently coloured even when living in what seems to be an identical environment; usually different parts of the same colony differ in colour. The brown colour of some of the corals is often due to the presence in the tissues of the body of great numbers of minute single-celled plants. Most corals, except those found in deep water, have

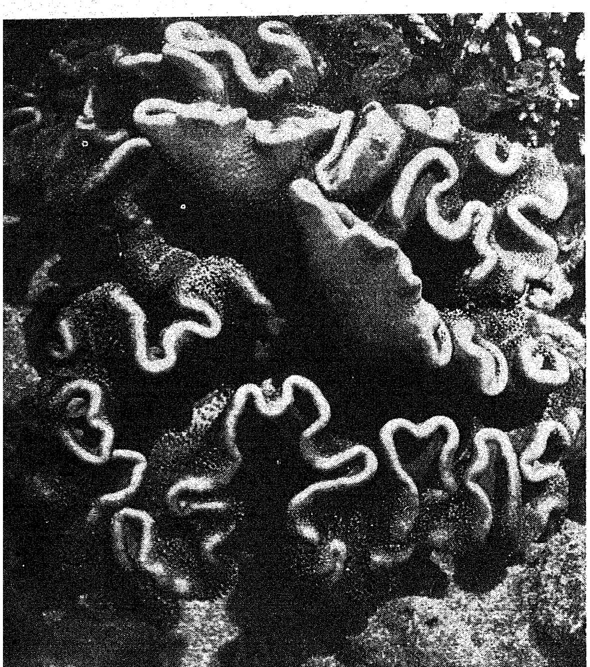


Plate 75. *Sarcophyton*, a soft coral
lyps are expanded in some parts and contracted in others.

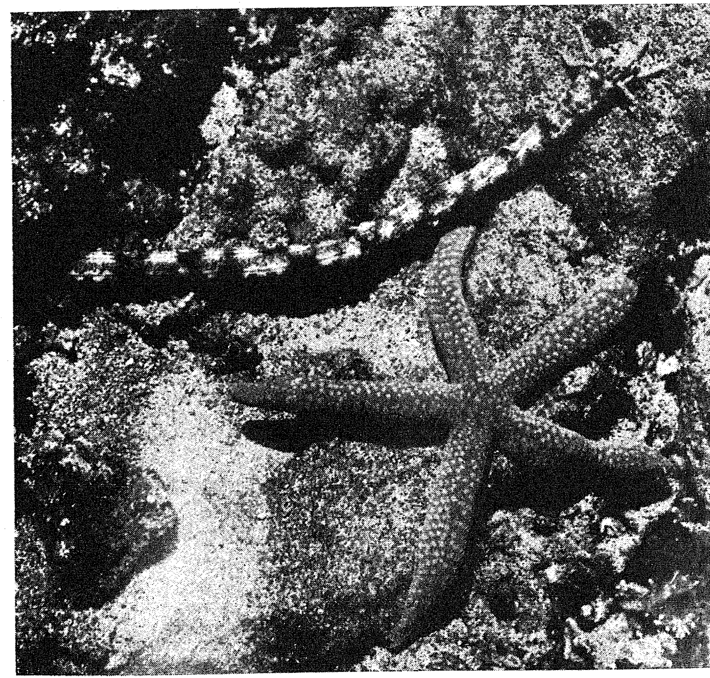


Plate 76. Two reef-dwelling animals
Above is *Synapta*, a sea cucumber, allied to the species which is d
for food (*bêche-de-mer*) ; below is *Linckia*, a brilliant blue starfish.

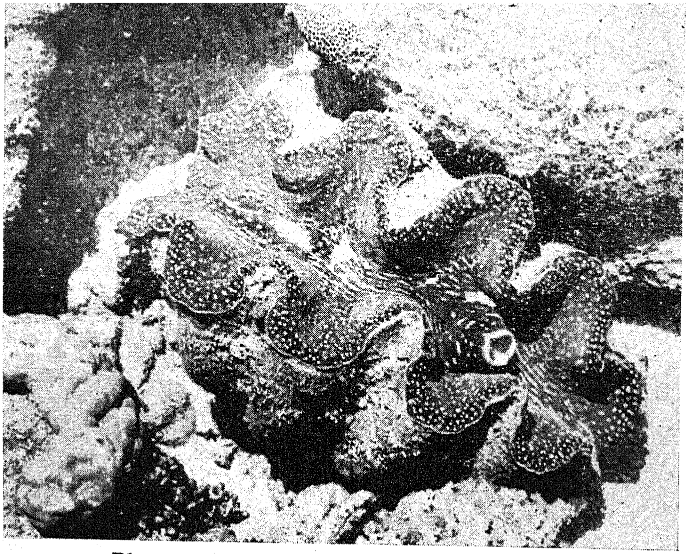


Plate 77. The giant clam (*Tridacna deresa*)
The specimen is viewed from above. The valves of the shell are gaping, showing the mantle which is brightly coloured, green with golden flecks. The slit-like inhalent siphon and the spout-like exhalent siphon can be seen.

some of these algae which appear to be capable of living only in partnership with their animal hosts, where they are passed from parent to offspring. The plants absorb waste products of the corals' metabolism and use them to build up their own tissues in the presence of sunlight. Although the corals cannot feed on them, they seem to benefit by their presence as they grow more vigorously when they have algae than they do in deeper waters where they have none. The giant clam (Plates 77–8) has exploited an association with algae more completely and even has special lenses which concentrate the light on to the algae in its soft tissues. The clam, unlike the coral, uses the algae for food and it may be this extra supply of food that enables the giant clam to reach such a very much larger size than other bivalves. (The shell may be 4 ft. across and the whole animal weigh 5 cwt.)

Barrier reefs and atolls have arisen in a number of different ways in different places although their appearance to-day may be similar. Most of them have grown up in association with land subsidence, although some have been formed as a result of elevation of the sea floor. The geological history of reefs is dealt with in Chapter II (pp. 42–8). The biological processes may, however, be described here. Reef-building corals require a temperature of at least 70° F. and can only flourish where there is light and abundant plankton food, so they are confined to shallow water of 30 fathoms or less between 30° N and 30° S. But except for the western shores of continents they are found in all shallow waters between these latitudes where there is a solid substratum for their foundation. Corals once established will grow upwards until they reach the level of low water. Only the upper parts of the mass will be living, the corals continually adding to their dead skeletons below them. Broken-off portions of coral and dead skeletons are cemented together into compact rock by calcareous algae and in other ways. Such a mass of coral with a flat upper surface has steep sides going down to the sea floor below the 30 fathoms contour. It is subjected to the unceasing action of the sea and pieces of coral are constantly being broken off. Some of the resulting debris is hurled on to the reef flat behind the seaward edge of active growth. It becomes broken up into coral gravel, sand and finer particles, which accumulate on the leeward side, forming a gentle slope to the sea floor. The sand may accumulate to form a bank above sea-level, and in turn the sand may be cemented into beach rock and land plants may colonize the island so formed. Extension of the slopes of debris around the growing reef will widen

the foundations of the reef until the 30 fathom level is reached; and so the reef grows outward, living coral being supported by the consolidated remains of the dead. As the coral area increases, the colonies in the centre of a reef flat find themselves further and further from the open sea. By the time the ocean currents reach them the water has passed over so many other colonies, with all their millions of polyps spreading their tentacles fishing for plankton, that there is little food left for them in the centre, and they weaken and die. It is probably abundance of food rather than oxygen that causes corals to flourish so vigorously in the rough outer waters. The dead coral on a reef flat is either overgrown or broken up in many way. Molluscs, worms, sea urchins, barnacles and algae burrow into it and it is broken up into small particles. The calcareous sand so formed is carried away by water movements and dissolved or deposited elsewhere, forming lagoons and sandbanks.

Animals Associated With Coral Reefs

Reef coral forms the basis for a wealth of animal life unequalled elsewhere. Food is abundant and there is excellent protection and concealment, the coral rock being permeated with pores and hollows, cracks and interstices.

The shoals of little fish swimming in and out among the corals, the sea cucumbers (Plate 76) and sea urchins creeping over the bottom, the tube-worms protruding their crowns of delicate tentacles from their burrows, the sedentary animals like barnacles, sea anemones, sponges and the corals themselves; and all manner of crustacea and molluscs creeping in and out of crannies, each display the most brilliant colours. Sometimes the colours merge with the background; but many of the fish have bold patterns of vivid blue, scarlet, or intense purple or yellow, which stand out against the background. These fishes may be distasteful, or they may be imitating distasteful species. Certain types of colour pattern and body form are repeated by species of quite unrelated groups of fishes. Other fishes belonging to different groups, including porcupine fish, puffers and parrot-fish, have their teeth consolidated into powerful beaks which enable them to browse on the coral. The molluscs are characterized by especially thick shells. Among bivalves are oysters, pearl oysters and the giant clam. The univalves include a great many species often restricted in their geographical distribution. Many like *Trochus* are quite large and have shells of commercial value. Holothurians (sea cucumbers) are sufficiently abun-

dant in some places to form the basis of a fishing industry. Their dried bodies, known as *bêche-de-mer*, were formerly exported to China in large numbers (pp. 273–5). Some of the crabs affect the coral in such a way that it grows up around them, imprisoning them in a little cage-like gaol.

The richness of the fauna is not everywhere the same. The Tuamotu archipelago shares the poverty of the eastern part of the open Pacific. There are fewer species of coral, the fleshy alcyonarians appear to be missing, and the giant clams are comparatively small.

Mangrove Associations

In and upon the mud among the tangle of mangrove roots is found a remarkable assemblage of marine, freshwater, and terrestrial animals. Small sea anemones are found in little pools near the water's edge. There are millions of crabs of various kinds creeping in and out among the roots and generally coloured to match the bark. Fiddler crabs make burrows everywhere. There may be tree oysters attached to the roots and there is a whole series of univalve molluscs, the species becoming more and more tolerant of freshwater and terrestrial conditions as the height above low water increases. Buried in the mud are bivalve molluscs and worms. When the tide goes out a great many ants, crickets, and other insects invade the mud from their nests in the trees, and birds from woods inland may join them, looking for food. The curious air-breathing fish *Periopthalmus*, the mud-skipper, is often conspicuous, living as much out of the water as in it and feeding on small crabs and insects. Its eyes are placed high up on the top of the head, as in many other amphibious animals, so that vision above water is possible while the rest of the body is submerged.

Effects of Seasonal Changes on Pacific Fauna

So far we have considered differences in the environment between one place and another, and it may now be worth while turning our attention to the responses of animals to the changes in the conditions of living from one season to another. The area under consideration is predominantly tropical and there is very little change in climate from one season to another. The temperature, particularly near the equator, is very constant; in some places there is less than 2° F. difference between the mean temperature of the hottest and coldest months. Many Pacific islands are wet at all seasons, and the driest months are often nearly as wet as the wettest. Many of the animals

as a consequence have no definite breeding season; but there are some cases where this is astonishingly sharply defined. There is an insectivorous bat which lives in caves in the almost unvarying climate of Hog harbour in the New Hebrides. All the females of this species in a sample investigated had conceived at the same time to within a few days. Even in a temperate climate no mammal could have a more sharply defined breeding season. The breeding habits of the fruit bats of the Pacific islands have not yet been adequately worked out; but what information there is confirms the impression gained by a study of species in other lands—that there is a general tendency for the young to be born about March to April north of latitude 4°N and about September south of latitude 3°N. The concepts of autumn and spring seem to have a biological significance even near the equator where the fruit bats continue their habit of mating in the autumn and giving birth to their young in the spring.

The tides have a profound influence on the habits of those animals that live between the tide marks. The tides in the Pacific are not high. In many places there is only one appreciable tide in the 24 hours (Appendix III). The hour of high tide changes slowly, so that for half the year the low tide occurs at night and for the other half in the day time. Thus, corals left uncovered are exposed to the heat of the sun and many forms are killed off at the latter season.

Many marine animals respond not so much to the seasons of the year as to the phases of the moon, very often spawning at a particular phase. This phenomenon is well known in temperate latitudes; but perhaps the most striking example occurs in the shallow waters of Pacific reefs. The palolo worm is a bristle-worm which lives in crevices among corals all the year, and the head end remains there at all times. But in islands in the Samoa and Fiji area, at dawn on precisely the day before, and the day of, the last quarter of the moon in the months of October and November—that is, four days in all—the hind ends of the worms separate off and swim in vast swarms to the surface where they spawn. The natives of the islands relish them as food and scoop them up in special baskets. In Savai'i the land crab *Gecarcinus* marches down to the sea to breed three days before the palolo worms appear. What the palolo responds to is quite unknown. It cannot be the state of the tide, for worms placed in floating tanks cannot be affected by it, but still spawn at the proper times.

Migrants either come into the Pacific area or leave it for their breeding season. Whalebone whales feed in the rich waters of the

Antarctic in the summer and migrate northwards to subtropical waters to breed in the winter. There is little food for them here, and whales caught in these waters are often thin and ill fed.

The most striking migrations in the Pacific area are naturally those of birds. The long-tailed cuckoo is confined to New Zealand (where it breeds) from October to March; and for the rest of the year it flies to the Pacific islands, including the New Hebrides, New Caledonia, Fiji, Samoa and the Society islands. More remarkable, however, are the migrations of the Pacific golden plover which breeds in Alaska and Siberia in the summer and for the rest of the year spreads over an immense area including China, the East Indies, New Guinea, Australia and New Zealand, and also the central and south Pacific islands. It even reaches the Hawaiian islands. To fly there from the breeding area it has to cross not less than 2,000 miles of open sea, and must fly continuously without rest or nourishment for at least two whole days and nights. Marked birds have been known to fly 3,000 miles in 10 days.

At some islands the arrival of migrant birds serves the natives as a seasonal index. For example, in Tikopia, the turnstone, which is heard overhead about October-November, is known as 'man of the monsoon', and its arrival is taken as an indication that the time for digging yams and performing certain seasonal ceremonies is near.

Fauna of Economic Value to Man

Apart from the introduced fauna, such as cattle, goats, pigs, dogs and poultry, which need not be discussed here, many of the animals of the Pacific have been drawn upon by man to serve his economic ends, as for food, tools or ornament.

In many of the islands the land fauna is not of great economic value, but marsupials are caught for food in New Guinea. Bats are usually regarded as pests, especially the fruit bats which raid cultivations; but their flesh is eaten by some peoples, and their fur is sometimes manufactured into string, or their teeth used for ornament. Birds in most areas do not form an important part of the food supply, but in some islands they are taken for food as opportunity offers, and, especially in the Western Pacific, their plumage is used for ornament at dances and on ceremonial occasions. Sometimes their capture is treated primarily as a sport; sometimes they are taken in order to be kept as pets. For example, in Tikopia noddies and a type of small martin are netted for food at certain seasons of the year; in Samoa and Tonga pigeon netting or snaring

was formerly an amusement of chiefs; in parts of New Guinea the flesh of the cassowary is used for food, its feathers for decoration and its bones for knives and daggers; in Nauru and Ocean island frigate birds are captured by a weighted cord and tamed as pets, being fed with fish by their owners, while in some of the Ellice islands they have been used like pigeons for taking messages.

Of much more importance to the Pacific islands natives is the marine fauna. Fish, shellfish, crabs and octopuses in great variety are used as food. Among the more important kinds of fish eaten are: the bonito or tunny; mullet of various types, including red, silver, yellow and grey; flying-fish; eels; rock groupers; various

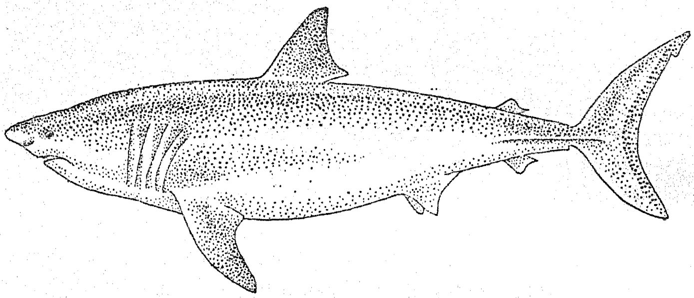


Fig. 75. Great white (or man-eating) shark

This shark grows to lengths of up to 40 ft. Most species of sharks do not usually attack man, but the white shark is noted in the Pacific for its man-eating propensities. In revenge, however, some native peoples take this shark, as well as others, for food. Based on J. R. Norman and F. C. Frazer, *Giant Fishes, Whales and Dolphins*, p. 19 (London, 1937).

scombroids, including one very similar to the European mackerel; snapper; sharks (Fig. 75) and rays. In the central Pacific, especially, the 'castor-oil fish' (*Ruvettus*)—so-called because of the cathartic effect of its flesh when eaten—is of some importance, and the suggestion has even been made that it may form the basis of a commercial fishery. In the past, shellfish have been valuable not merely as food; the native economy of the central Pacific, where there is usually no volcanic rock, has depended largely upon them for tools. Adze blades were made from the shell of the giant clam (*Tridacna*); bonito-hook shanks from clam shell or pearl shell; and sometimes borers from species of the long *Terebra*. Pearl shell and clam shell are still commonly used as ornaments in the Western Pacific, and in parts of New Guinea a type of large univalve shell is worn by men as a penis case. Some large marine shells and strings of small discs

made from shell are also important items of trade and social display in New Guinea and other islands of the Western Pacific. Turtles also are used as food, and their shells are used for the manufacture of bonito hook barbs and for a variety of nose and ear ornaments (Plate 108). A few kinds of land crabs and many of marine crabs are taken for food. A striking case of the utilization of marine fauna is the collection of the palolo worm (p. 442) at its periodical spawning period by the people of Samoa and Fiji.

Marine animals have also played an important part in the economic development of the Pacific area. Whaling (pp. 290–1) attracted many Europeans in the early part of the nineteenth century, and the collection of trochus, 'green-snail', the holothurian *bêche-de-mer* (pp. 273–5, Plate 84), and pearls and pearl shell for export has helped to provide a living for considerable numbers of natives, Europeans and Asiatics.

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Chapter VIII

HEALTH

Distribution of Insect Life: Insect-borne Diseases: Other Diseases: Sanitation, Water Supplies and Nutrition, and Associated Diseases: Depopulation: Medical Organization: Bibliographical Note

The medical conditions on these islands present certain peculiarities which are governed by the geographical factors of huge distances and poor communications, by the nature of the insect fauna, by the customs and beliefs of the peoples, and by the introduction of disease by the white man.

Distribution of Insect Life

Of these factors perhaps the most interesting is the distribution of insect life, which directly affects the health conditions of the populations in respect of those major diseases, such as malaria and filariasis, which are conveyed from man to man by biting insects.

In Malaya, Indo-China, and the East Indies there is a rich and varied mosquito fauna, with a large number of species of *Anopheles* mosquitoes which are active transmitters of malaria. The distribution of many of these species ends somewhat abruptly between these countries and New Guinea, and in New Guinea and the islands in its immediate neighbourhood only four species exist which are important in this respect, *Anopheles punctulatus*, *A. punctulatus* var. *moluccensis* (both ubiquitous breeders, choosing water exposed to the sun, in pools or placid streams), *A. barbirostris* var. *bancrofti* (which prefers the shadowed water of streams), and *A. annulipes* (breeding in pools, marshes, creeks and occasionally in brackish water). Though the vectors are few, however, the amount of malaria they cause is, in some areas, very great. These mosquitoes readily attack man and may be present in large numbers around their breeding places.

Further to the east, the only vector of malaria in the Solomon islands is *A. punctulatus*, which here breeds in sun or in shade in small collections of water such as are found in hoof marks, cart ruts, and in swamp land; large pools are often free from the larvae of this species, possibly owing to the presence of some animal or fish which preys upon them. The same mosquito occurs in the New Hebrides, and in all these islands malaria is found in heavy incidence.

Further to the south-east, in New Caledonia and the Loyalties, neither *A. punctulatus* nor any other known vector of the disease is found, and malaria does not occur. To the north, in Nauru and in the islands under Japanese mandate, the Marianas, Carolines and

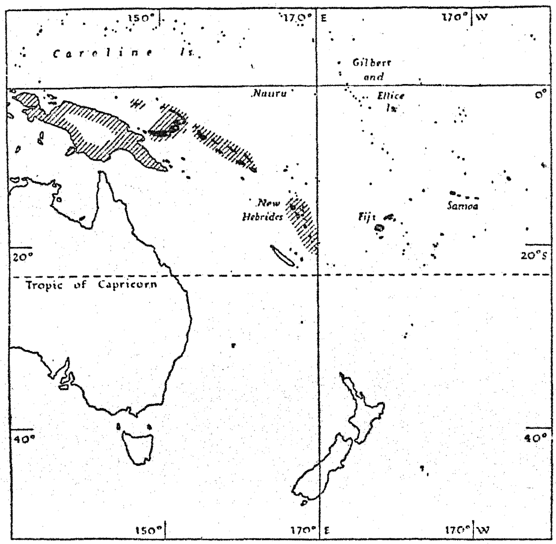

Fig. 76. Distribution of malaria in the Western Pacific

The area is bounded to the north by the equator and to the east by long. 170 E. Based on various sources.

Marshalls, *Anopheles* mosquitoes and malaria are similarly absent. Polynesia as a whole is free. Malaria is thus confined to the area bounded to the south by latitude 20°S and to the east by longitude 170°E, and it is not, in fact, common in these regions north of the equator (Fig. 76).

This line of longitude, 170°E (sometimes scientifically known as Buxton's line), is also important in that it forms a line of demarcation in two other diseases, filariasis (Fig. 77) and tropical phagedaenic ulcer. West of this line the type of filariasis (a disease caused by a worm whose embryos are carried from man to man by mosquitoes) is the same as that found generally throughout the tropical regions of Asia, Africa and America. The causative worm is *Wuchereria bancrofti*, and the embryos are found, in human blood, in large numbers at night but in very small numbers by day. This type of filariasis is therefore described as nocturnal or periodic, and it is

carried by mosquitoes which bite at night. Several genera and species of mosquitoes are involved in the transmission of this disease; in

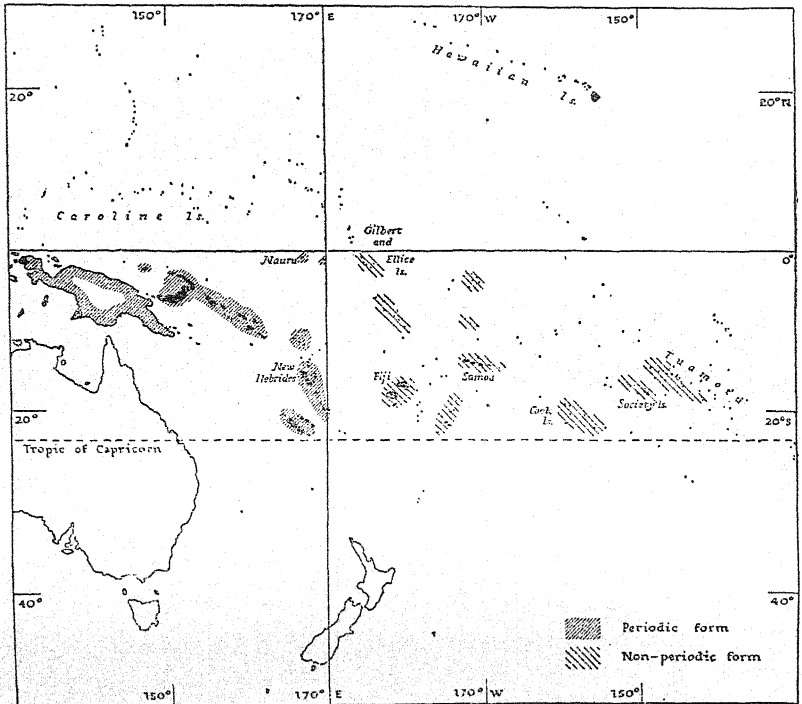

Fig. 77. Distribution of filariasis

Based on various sources.

New Guinea and other islands there is reason to believe that the *Anopheles* species which carry malaria also carry filariasis.

One of the results of human infestation with *W. bancrofti* is the gross and striking condition known as elephantiasis. This does not arise in all infected persons, and it is stated that west of 170°E, though filarial infection is common, elephantiasis is relatively rare, though a good deal is seen.

East of 170°E, however, the position is very different. Here, although so far as can be ascertained by careful study of the worm and its embryos there is no specific difference between it and the *W. bancrofti* found to the west, the infection does not show nocturnal periodicity. Embryos are as common in the blood by day as by night. The disease is not transmitted by *Culex* or *Anopheles* mosquitoes, but

only by *Aëdes*, especially the day-biting *Aëdes variegatus*. Filariasis in the Eastern Pacific is very commonly accompanied by elephantiasis. In the view of one authority, these differences are enough to justify the view that the *W. bancrofti* found respectively west and east of 170°E should be regarded as separate varieties of the species.

With regard to tropical phagedaenic ulcer, a condition whose cause is not clearly known, but which affects the legs of natives, especially plantation labourers and those subsisting on a poor diet, it is stated that though it is common to the west of 170°E, it does not occur to the east of that line.

Longitude 170°E, therefore, forms a striking boundary of these diseases. But, except in the case of tropical ulcer, it is probable that it does this by virtue of the fact that it is the natural limit of certain mosquitoes, for other diseases such as yaws, tuberculosis and leprosy are as common to the east as to the west of the line, but they are spread from man to man by other means than the intervention of insects. If the mosquitoes of the west become established in the east, as they may do, there is no reason to suppose that the incidence and nature of the diseases they carry will not change *pari passu*.

Insect-borne Diseases

Malaria

In the regions in which it is found, malaria is a high cause of infant mortality and of adult sickness. Where it is most prevalent, and where the carrier species of mosquitoes abound throughout the year, infection of the entire native population takes place in infancy; and since prevention of infection is not understood by the untaught natives, and effective treatment is unknown to them, the constant reinfections experienced by the infants frequently prove fatal. Children who survive, however, after going through a long period of ill-health with recurring attacks of the disease, gradually acquire immunity, so that in adult life, although malaria parasites may be present in the blood, attacks of fever are comparatively rare.

In areas where the breeding of the carrier mosquitoes is not continuous, but is governed by seasonal conditions of rainfall (since mosquitoes breed only in water), the transmission of malaria on a large scale is also seasonal, and there may be months during each year when the disease does not spread. Under these conditions the infant mortality from this disease is not so high, but the immunity acquired, which depends for its maintenance upon the frequent repetition of infection, is incomplete. In such areas, therefore, it is

common to find that even in adult life the natives suffer from attacks of malaria during the transmission season, which is usually the rainy season.

These facts are of more than academic interest. Thus, natives, including troops or bodies of labourers, recruited in areas where malaria is a seasonal disease, and transferred to areas in which it is perennial and severe, must be expected to suffer seriously, and even, if not adequately cared for, to experience a high death rate from the disease and from other diseases to which malaria predisposes. Natives from islands in which malaria is not known, and Europeans, possess as a rule no acquired immunity, and if taken to malarious areas must be expected to suffer as much as native infants.

Three forms of malaria are found in the malaria quadrant of the Pacific ocean. Subtertian is the most severe and widespread, benign tertian is common, and quartan is found in New Guinea, where its distribution is patchy, and in the Solomons. In New Guinea and Papua the coastal districts are usually intensely malarious, though the delta region of western Papua is an exception to this rule. Inland there is a malaria-free belt and the Papuan peoples found inland from Yule island are free from the disease. These people are not recruited for coastal labour because the mortality from malaria, when they are transferred there, is high. Subtertian malaria is abundant in the mountains behind Port Moresby.

Although common in most parts of Melanesia, malaria is usually absent from the atolls of this area—even from those near the larger malarious islands. Most of the malaria-free islands are coral, and it may be that the porous soil offers no favourable breeding places for *A. punctulatus*, the only malaria carrier which has been able to establish itself beyond the eastern borders of New Guinea. Thus, in the New Hebrides, malaria is found in all islands except Futuna; in the Solomons it is widely prevalent, but is not found on Tikopia and Anuta. Wherever it occurs, it is an important (usually the most important) health problem. In the New Hebrides, though the incidence is not so heavy as in New Guinea and the Solomons, there are seasonal exacerbations, usually from November to May, when the disease becomes epidemic. A spleen rate of 28.6% has been recorded, which may be compared with that of 80% in the Solomons (Fig. 78). (The spleen rate is the proportion of children under 10 or 12 years whose spleens are enlarged; it is a measure of the amount of malaria.) These figures, however, should not be regarded as definite indications of the amount of malaria. It is evident from what has been stated

above that this disease too often fluctuates according to climatic conditions and other factors for any definite indication to be given as to its prevalence.

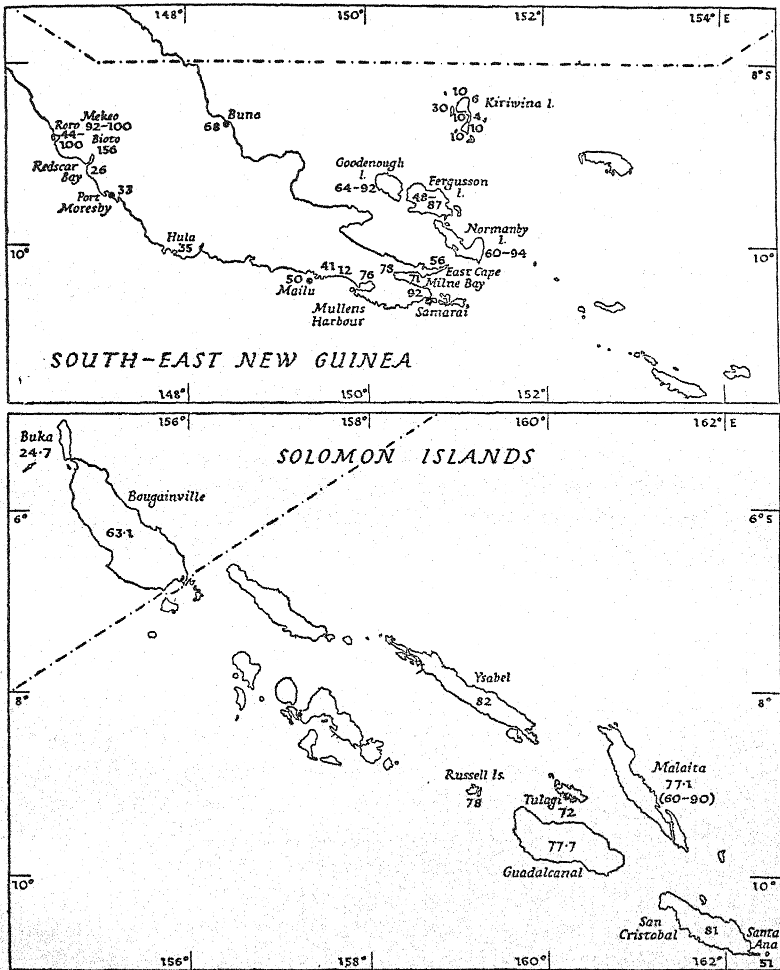

Fig. 78. Spleen rates: south-east New Guinea and Solomon islands
The New Guinea map is based on surveys by the following: A. Breinl and F. W. Clements (1935); E. Ford (1938–9); N. H. Fairley and I. M. McKerras (1942; unpublished).

Blackwater Fever

Blackwater fever is a sequel, fortunately comparatively rare, of

subtertian malaria. It is a disease of high mortality and usually arises in non-immune persons, such as Europeans, living in highly malarious areas; it is reported from New Guinea, the New Hebrides and the Solomons.

Filariasis

Filariasis is generally prevalent throughout the islands of the south Pacific, from New Guinea to the islands of French Oceania. It is not mentioned in reports from the Marianas, Carolines and Marshalls, or from Guam; and it is absent except as an introduced disease from the Hawaiian islands. Its maximum prevalence is on, or south of, the equator. As has been stated above, west of longitude 170°E the infection is by *Wuchereria bancrofti* of nocturnal periodicity, and here, although the gross effects of infection are seen, they are not so common as in the islands east of that line where the infection is non-periodic. These effects consist of the condition of elephantiasis, in which limbs or scrotum may be enormously enlarged, or of slighter conditions of similar nature, and with these are associated periodic attacks of fever and inflammation of lymphatic vessels. Elephantiasis may therefore be a very disabling disease. It should be understood that many more persons harbour the worms, and show embryos in their blood, than give evidence of elephantiasis.

In the western part of the area it seems probable that the periodic nocturnal filariasis is transmitted mainly by *Anopheles* mosquitoes, the breeding-places of which have already been mentioned. The common carrier of the non-periodic eastern form is *Aëdes variegatus*, which breeds in rain water collected in the shells of coconuts, or in tins, bottles or other small receptacles, and in tree-boles; it is apparently necessary that the water should contain some decaying vegetable matter. In Samoa, the Ellice islands and Fiji, this mosquito is known to be the only vector of filariasis, and it is probably the only vector in the Tokelau group, Tonga, the Cook islands and the Tuamotu archipelago. It is worth noting that *Aëdes variegatus* bites by day and is thus able to pick out from human blood the embryos of *W. bancrofti* of the non-periodic form, which are present both by day and by night, whereas the *Anopheles* mentioned above as carriers of the periodic form, bite by night, at the time when embryos swarm in the blood of infected persons, in whom the day blood is relatively free.

Examinations of blood have been made in many islands to determine the amount of filarial infection. The periodic form is not very

common in parts of Papua, though in some areas of New Guinea infection may be present in 100% of the population. In the Solomons, 15% infection was found by one observer. It is reported to be fairly common in the Santa Cruz islands. In the New Hebrides the figure of 31.4% is given.

The non-periodic form has been found as follows: Samoa, 58%; Ellice islands, 60%; Tonga, 37%; Fiji, 32%; Tokelau group, 37%; and Cook islands, 34%. It is reported as becoming prevalent in the Gilberts and as widespread in Rotuma. Elephantiasis (and therefore the parent condition of filariasis) is very common in the Tuamotu group.

Of the effects of filariasis little more need be said. It is a disease which develops exceedingly slowly and which in its early stages produces little disability, but which, when elephantiasis is established, may give rise to such enormous enlargements of limbs or scrotum that bodily activity is most severely restricted. There is no known drug which will eradicate the worms or their embryos, but in certain types of elephantiasis surgical removal of the enlarged parts is possible. Although filariasis has recently been reported in European troops in the Pacific area, it cannot be regarded as a bar to the movements of troops or of labourers; there is no reason to suppose that any effective immunity is acquired, as in malaria, by constant re-infection.

Dengue Fever

Dengue fever, a trivial but painful fever, is found throughout most of the Pacific islands. It has been rife at times in the Japanese mandated islands, it is known in New Guinea, Papua and Fiji, and in Samoa there was an extensive epidemic in 1930. In New Caledonia and French Oceania it occurs, but is rare. Dengue is caused by a virus which is transmitted from man to man by the mosquito *Aëdes aegypti*, but there is reason to think that, in Samoa, *Aëdes albopictus* is also a vector. *Aëdes aegypti* (which is also the vector of yellow fever in those countries in which that disease exists) is found breeding in domestic collections of fresh water, such as cisterns, tanks, rainwater butts, throughout the tropics, and especially in coastal areas. It is a mosquito which rarely breeds far from human habitations, and which attacks man freely.

Dengue may cause much temporary disablement in Europeans and immigrant peoples in the Pacific islands, but it is practically never fatal. Preventive measures are not seriously undertaken. If

yellow fever were introduced it might spread rapidly, since the mosquito carrier, *Aëdes aegypti*, is very widely distributed. *Aëdes aegypti* is known to occur in many parts of the East Indies, Melanesia and Polynesia, including the Hawaiian islands.

Other Fevers

Typhus fever has been reported as endemic in New Guinea but there is reason to believe that the form seen is not true louse-borne typhus, but the mite-born form which elsewhere is known as tsutsugamushi disease or scrub typhus. It is contracted in bush country and does not usually become epidemic in man. A few cases of flea-borne (or murine) typhus have been reported from Honolulu. From New Caledonia there is a report of a single case of *relapsing fever*, the vector being presumably the louse, but it is suggested that this disease may actually be more prevalent than is suspected. *Rat-bite fever* is reported from the same area and also from New Britain.

Human Plague

Human plague has been reported, in recent years, from the Hawaiian islands. There it is endemic, a few cases occurring each year ; infected rats are constantly found in two main areas, one along the coast of Hawaii in the Hamakua district, the other in the central section of Maui. There is a recent report of eleven cases of plague from New Caledonia.

Other Diseases

Yaws

Yaws, a disease caused by a spirochaete indistinguishable from that which produces syphilis, and transmitted by personal (though not usually sexual) contact, was at one time the most common cause of sickness throughout the islands of the south Pacific, regarded as a whole, and was equally common in the Japanese mandated islands, though rare in the Hawaiian group. In the islands affected by malaria the amount of sickness due to yaws is probably not so great as that due to malaria, but elsewhere yaws has in the past exceeded all other diseases. Owing to the mode of spread, yaws is not limited, as are malaria and filariasis, by geographical boundaries of mosquito fauna. It is usually acquired in infancy or childhood, at which period the acute signs are seen, and often persists in a chronic form into adult

life, when the late results may cause trouble. Yaws is not usually a fatal disease, but may lead to severe disabilities. It shows itself first as a crusted sore, which is accompanied by some fever. Later, in the secondary stage, the infection spreads throughout the body and there appear crops of similar sores having a very characteristic appearance. In the tertiary stage, which may not occur, or which may be delayed for some years, there may be changes in the bones or joints with deformity, or the destructive process known as gangosa may occur. In this condition the bones of the palate and nose are destroyed, with great disfigurement. Serious results of yaws, however, are comparatively rare.

Reports indicate that yaws is particularly common in the New Hebrides, Solomons, Ellice islands, Fiji, Samoa, Tonga and the Cook islands. Visible signs, and symptoms, show that 50 to 75% of the inhabitants have been affected, but in Samoa and the Ellice islands—and probably elsewhere—infection was until recently regarded as universal. In French Oceania, however, yaws is stated to be rare. Whether this is indeed so, or whether the statement is due to the difficulty in differentiating certain types of yaws and syphilis, is not certain.

The control of yaws consists almost entirely of a system of intensive treatment with arsenical drugs or bismuth compounds, and this has been undertaken on a large scale in many islands, with considerable success.

Within the last twenty years vigorous campaigns have been conducted, particularly in Western Samoa, the Ellice islands, and the Tokelau group, in which treatment has been carried out by visiting teams of medical men and assistants. These tours are highly popular and the results very marked ; and the evident improvement brought about by modern treatment has played a great part in convincing the inhabitants of the value of Western medicine in general. The result is that yaws is now much more rare and many of the crippling disabilities to which it may give rise have almost been banished.

Syphilis

Syphilis is not common in the Pacific islands. As is stated above, the organism which causes yaws is indistinguishable from that which causes syphilis, and there is enough similarity between the diseases to cause confusion in diagnosis in certain cases, though in most respects the two can be distinguished. A diagnosis of syphilis is

often made by French physicians when in British opinion the disease is yaws. Syphilis is almost unknown in Fiji, the New Hebrides, the Ellice islands, Samoa and the Tokelau group ; it is not reported from the Japanese mandated islands, is stated to be unknown in the Solomons, and is probably rare in New Caledonia and the Loyalty islands. It is recorded as common in Tahiti and the Mangareva group ; it is apparently rare in the Tuamotu archipelago ; and it is stated to be common in Uvea (Wallis island) and Futuna (Hoorn islands), but, as these are surrounded by other islands in which the disease is almost unknown, the accuracy of the diagnosis may be questioned. It is common in Hawaii.

In Fiji it was at one time common among Indian immigrants, but did not spread to the Fijians. Chinese immigrants in several islands suffer from syphilis, as do Tonkinese immigrants in the New Hebrides.

This freedom of the native peoples from syphilis is a striking phenomenon, since the other principal venereal disease, gonorrhoea, is by no means scarce. It has been stated above that yaws and syphilis are caused by organisms which are microscopically indistinguishable, though there is very good reason to believe that the two diseases are different. Yet the great prevalence of yaws is associated with a remarkable rarity of syphilis, which has led to the widely held opinion that infection with yaws gives immunity to syphilis. It is evident that no such immunity exists in the immigrant Asiatics named above.

Syphilis is often transmitted from parents to their children, in hereditary fashion, and in other parts of the world is a potent cause of infant mortality and is responsible for a high proportion of still-births. In the Pacific islands, where depopulation has been so important a social factor, it is evident that the blame cannot be laid upon syphilis.

Gonorrhoea

Gonorrhoea is in a very different category. In general, its incidence is high. In the Japanese mandated islands about one-third of the people are affected, and it is found even in children ; in Papua and New Guinea it is common, especially in the east ; in the Solomons the distribution is patchy but it is not uncommon ; it occurs in the New Hebrides, New Caledonia and the Loyalty islands (where it is found especially in Javanese labourers). In the Gilbert and Ellice islands gonorrhoea is not common ; and in Fiji, though common, it

is apparently mild in character. In Samoa there is not much, and it is apparently comparatively rare in Uvea (Wallis island), Futuna, Tonga and the Cook islands (except Rarotonga). In French Oceania almost every adult is, or has been, affected.

Gonorrhoea is responsible for much ill-health in adults, for sterility in women, and for blindness through the infection of the eyes of infants at the moment of birth. It may be a considerable factor in the widespread process of depopulation in the Pacific islands. Control is exceedingly difficult, especially in view of the indiscriminate sexual intercourse of the inhabitants of many of these islands, but it may be hoped that the effective drug treatment recently discovered will help, in time, to reduce the incidence of this disease.

Other Venereal Diseases

Other venereal diseases are much less common. *Venereal granuloma* is reported from New Guinea, the Solomons and the New Hebrides, but not from Polynesia ; in parts of Papua it is said to be so common that it threatens certain villages with extinction. Treatment is difficult, but fortunately this disease does not appear to spread so quickly as gonorrhoea.

Tuberculosis

Tuberculosis is, in many islands, the principal cause of death in adults. All forms are found, but the commonest, and most fatal, is tuberculosis of the lungs. In this condition the causative bacilli are present in the sputum and may be expelled, from the focus of disease in the lungs, through the mouth and into the air during the acts of talking, coughing or sneezing. Infection is acquired by the inhalation of air containing these bacilli, and it is therefore evident that the chances of infection are greatest in those persons who live in close contact with patients suffering from the disease. Tuberculosis, therefore, is a family disease, and it is found to be so in the Pacific islands. Spread within families is easily understood when it is remembered that the common practice is for all members to sleep together in close proximity. Infection from the consumption of tuberculous milk, such as occurs in Europe, is almost non-existent there.

In general, tuberculosis of the lungs is more rapidly fatal in Melanesians and Polynesians than in Europeans, whether from inborn lack of resistance or from ignorance of the value of rest in treatment. Tuberculous meningitis is equally fatal in Europe and in the Pacific.

but tuberculosis of the lymph glands, bones and joints, in both hemispheres, follows a relatively benign course. The pulmonary form affects chiefly adolescents and adults, the other forms are more common in children. It is thus true to say that, in the Pacific, the highest death rates from this disease are experienced during the productive and reproductive years of life, and that there is probably a significant effect, through tuberculous meningitis, upon infant mortality.

It is stated that tuberculosis in Samoa is particularly prevalent in mixed-bloods.

In the Japanese mandated islands and Guam tuberculosis is reported as being fairly common—in the former it is estimated that it causes over half the deaths on the islands. In Papua and New Guinea it is common among plantation labourers but is rare in the more remote districts. In the Solomons all forms are seen and tuberculosis is regarded as a serious menace; in the New Hebrides, however, it is stated that the disease is not so prevalent as in some of the other island groups, though the incidence is still fairly high. In New Caledonia and the Loyalty islands tuberculous glands are rare and other forms are not so common as was at one time reported. In Norfolk island the incidence is high. In Nauru and Fiji the incidence is also high; in Fiji 90% of adults are positive to the tuberculin test, which, while not necessarily indicating disease, demonstrates that the positive person has been infected. This is about the same rate of infection as that found in London, but the incidence of disease and the death rate from the disease are higher in Fiji. In the Gilbert and Ellice islands the incidence is described as moderate; in Samoa the tuberculosis death rate is almost four times as high as in Great Britain, and tuberculosis is the leading cause of death; the same applies to Tonga. In the Cook islands and French Oceania the incidence is high, but it is stated that in the Tuamotu group there are not so many cases, relatively, as in the other islands. In Hawaii it is stated that the death rate from tuberculosis is almost three times as high in Hawaiians and Filipinos as in other ethnic groups, and it is noted that the use of pasteurized milk is extending and that the tuberculin testing of milch herds, with the object of eliminating tuberculous animals, is practised. In Hawaii the human tuberculosis incidence is reported to be declining.

The control of this disease in primitive peoples, who have no appreciation of the method of spread, is a most difficult problem. Treatment, even in Europe, is a long and often disappointing

business, and no dramatic cures can be expected. Prevention entails not only extensive change in the mode of life of the community, whereby the close contact which now exists between members of families may be reduced, but also a change in the dietary habits to ensure adequate supplies of vitamins and of animal fats and proteins.

Tuberculosis must be regarded as an important factor in the depopulation of the Pacific islands; that it can play an enormous part in the extermination of indigenous people brought into contact with Europeans is shown by the devastating epidemic among the North American Indians in the late nineteenth and early twentieth centuries.

Leprosy

Leprosy is akin to tuberculosis, in that the causative organism falls in the same group, and that both diseases are usually of long duration. Leprosy, however, is much less fatal than tuberculosis, is much less easily acquired, and is much less important from the point of view of depopulation. Nevertheless, since leprosy is very common and widespread in the Pacific islands, since lepers live for many years in a state of misery and incapacity, and since leprosy, like tuberculosis, is transmitted by close contact from parents to their children, this disease is one of very great importance in the area under consideration.

There are a few lepers on Guam and in the Japanese mandated islands, where asylums have been instituted on Saipan, Yap, Palau and Jaluit. In New Guinea leprosy is common; in New Ireland the incidence is reported as 11 per 1,000 of the population—in Lavongai as much as 59 per 1,000. In the Solomons leprosy is a serious problem, and it is reported to be spreading in the New Hebrides. In New Caledonia and the Loyalties it is regarded as the main health problem of the natives; 723 definite cases are known, of which 109 are in white people. In Nauru the incidence in childhood and adolescence is high, but is said to be slowly decreasing; in the Gilbert and Ellice islands the disease is common. Fiji, where there are many cases, possesses the best known leper institution of the Pacific. This is at Makongai, where there is accommodation for 400–500 lepers; patients are sent to this institution from many of the Pacific islands, and the work done is of a high order (vol. III, pp. 188–9). There is some leprosy in Uvea (Wallis island), but none was seen by one observer in Futuna.

Leprosy is not, apparently, so common in Samoa, Tonga and the Cook islands, though cases are found. No cases have been recently

reported in the Mangareva group, but the disease is reported to be spreading in the Marquesas, Rapa and the Tuamotu group (where there is a leprosarium at Reao).

In the Hawaiian islands leprosy is found but it is stated that the rate is declining, especially in young people. Here there seems to be no definite racial susceptibility, and it is noted that the disease is more common in rural than in urban communities, probably in consequence of the poorer sanitary conditions existing in rural areas. There is an institution at Kalaupapa on Molokai, and other receiving stations exist; in all about 800 cases are now under supervision (vol. II, pp. 354–5).

Skin Diseases

Skin diseases may be referred to at this point; they are exceedingly common throughout the Pacific, but are usually not serious. The most striking is *tinea imbricata*, a condition due to a fungus, which produces a scaly appearance very characteristic of the disease. It is common in the Tokelau group (the French name for the disease is, in fact, *tokelau*; and it has been called in English 'Tokelau ringworm'), New Guinea, the Ellice islands, Samoa and many other groups. Various *ringworms* are also seen, and *impetigo* and *scabies* are quite common; the latter is sometimes intense in New Guinea. On Rennell island there occurs, especially among visitors and immigrants, a kind of acute itch which is not scabies. This is most distressing while it lasts, and is followed by extensive peeling of the skin.

Infestation with head lice is common in the Solomons, Tonga, Uvea (Wallis island) and Futuna (Hoorn islands), and in many other islands.

Miscellaneous Diseases

In the early days of white penetration, diseases such as measles, dysentery and other infections were introduced into these native communities with disastrous results. This is still a possible danger in the remote spots where contact with outside peoples has been scanty.

Of the general diseases perhaps the most important is *pneumonia*, which is responsible for a high proportion of deaths throughout the area. *Bronchitis* is also generally common. *Influenza* attacks the islands from time to time, specially after visits by ships, which introduce the infection. The world-wide epidemic of 1918–19 caused many deaths in the Pacific area. *Measles* was responsible for

a widespread and fatal epidemic in Fiji in 1875 (vol. III, p. 144), since when it has been present in most of the islands. In 1936, a measles epidemic spread rapidly among the Gilbert islands and took a heavy toll of life. Beru island instituted a strict quarantine on shipping, and escaped the epidemic. *Chickenpox*, *whooping cough*, *diphtheria* and other infectious fevers make periodic appearances throughout the area. *Smallpox* cases have not been reported in any considerable numbers in recent years; vaccination is widely practised. *Infantile paralysis* is of some importance; there was an epidemic in the Solomons in 1925, and one in Nauru in 1910. In Hawaii cases are reported each year and there was a large outbreak in 1940, affecting white children especially.

Cerebrospinal fever is found sporadically, and *tetanus* has been reported from the New Hebrides and elsewhere. In Samoa there is a severe type of *jaundice*, with a high death rate, which was first reported in 1935. It is suspected that this may be a form of *leptospirosis*, and blood examinations in recovered cases confirm this view. An outbreak of *leptospirosis* has recently been recorded in Hawaii, affecting chiefly young sugar-cane cutters. The infection has also been found in Hawaii in dogs, rats and mongooses. In many islands *tropical myositis* (a condition in which abscesses form within the muscles, especially of the limbs) is a common condition of great severity. At one time this was thought to be a sequel of filariasis, but opinion now tends to regard it as a disease of itself, having no direct connexion with filariasis. It most usually affects adult males.

Of the *eye diseases*, *trachoma* is fairly widespread, and causes much impairment of vision. *Conjunctivitis* is common, and in Samoa there is a peculiar form which occurs in epidemics and which may be so intense as to destroy the eye; the infection may spread to the nasopharynx. The causative organism has been named *Diplococcus samoensis* and closely resembles the gonococcus, but is said not to be the same; it is constantly present in the disease. This conjunctivitis is not common near the sea shore or where bathing facilities are easily available. In the Ellice islands conjunctivitis is noted as an occasionally severe infection. In Papua there have been reported epidemics of *panophthalmitis* (inflammation of the whole eyeball), and it has been suggested that these were the result of lack of vitamin A.

Snake bite is common in Papua and New Guinea, but details of the poisonous species are lacking. Poisonous snakes do not occur on the majority of the Pacific islands. A form of *dermatitis* probably

due to a stinging coral animal is found near the Great Barrier Reef off Australia, and probably elsewhere among the atolls.

One of the important social problems of some of the islands is *alcoholism* due to spirits and other liquors obtained by the natives. Much of this is an introduced European vice.

Sanitation, Water Supplies and Nutrition, and Associated Diseases

Of the factors which influence the sanitary customs of the inhabitants of the Pacific islands one of the most important is belief in magic. In general the Papuans, Melanesians and Micronesians take care that their excretions cannot be obtained by an enemy, who might use them to their detriment. So strong is this belief that in some islands it is extremely difficult to collect specimens of faeces for examination. In sea-shore areas sanitation is satisfactory enough from the point of view of health, because of the custom of depositing faeces on the beach below high-water mark, as in the Solomons. In Samoa latrines are constructed over the sea. In the interior of many of the islands the natives use any convenient bush, and the pigs, which are kept in large numbers, act as scavengers, but cannot entirely prevent pollution of the soil. In parts of Papua, there exists a custom which forbids defaecation or urination near cultivated land, and the drinking of water from certain polluted sources, but otherwise there is nothing to indicate that the Pacific islanders realize the true dangers of faecal pollution.

Faecal contamination of soil is perhaps more important in many islands than faecal contamination of water supplies, since in some of the islands the water supply is derived solely from rain collected in tanks from the roofs of houses. Soil contamination is responsible for the hookworm infection which is widespread, though rarely intense, among the islands.

Samoa and Tonga are perhaps the most advanced in the matter of sanitation. In Tonga an extensive programme of pit-latrine construction has been put in hand; in Samoa, although soil pollution round plantations is serious, the use of over-sea latrines is common, and the same is true in the Gilbert and Ellice islands. In Papua and New Guinea latrines have been introduced for plantation labourers; in Fiji the position is difficult in the low-lying swamps where Indians work the land, but cesspits have recently been introduced,

and elsewhere bore-hole latrines are prepared. Suva has a sewage system.

Soil pollution may be roughly measured in these islands by the amount of hookworm disease present in the natives; pollution of water supplies by the amount of enteric fever and dysentery.

As has been stated above, rain water collected in concrete or other tanks is the main supply in some of the islands, for instance in the Japanese mandated islands, the Gilbert and Ellice islands, Tonga and the Cook islands. Often this water is badly collected and liable to some contamination. Native houses are usually covered with thatch and the water collected is dirty; there has in the past been a superstitious objection to the collection of water from church roofs, which are frequently constructed of corrugated iron, so that this valuable source has not been exploited. In recent years this objection has to some extent been overcome, and efforts have also been made to improve the roofing of native houses.

In many islands, and in the larger areas of land in New Guinea, however, streams exist and these are used for water supply. They are often contaminated, but it has been noted that in French Oceania the natives tend to separate their washing places in the streams from those used for domestic water supply. Shallow surface wells are constantly used; and these must inevitably be contaminated, not only by the pigs with which the islands abound, but also by the natives themselves in the act of filling their primitive vessels. Thus the interaction between lack of sanitation and unprotected water supplies becomes apparent.

Protected and piped water supplies are established in some of the more advanced places. There are good supplies at Apia in Samoa, Noumea in New Caledonia, and a very pure mountain supply at Papeete in Tahiti.

Hookworm Infection

Hookworm infection is a measure of soil pollution; it is widely prevalent in the Pacific islands, though the intensity of infection in most of them is not so great as in other parts of the world. The hookworm is a small worm, about half an inch in length, which inhabits the intestine of man. Its eggs are passed out in large numbers in the faeces and, under certain conditions of temperature and humidity, develop in soil into minute embryos which are capable of penetrating the skin of man, whence, by a devious course through the body, they eventually reach the intestine, where they mature. Hookworms suck

blood from the intestinal wall, and if present in large numbers, lead to anaemia which may be severe and which often leads to physical weakness and to increased susceptibility to other diseases. Indiscriminate defaecation provides the association of faeces and soil necessary for development of the embryos and affords opportunity for contact with human skin in persons who walk barefoot over contaminated places.

In the indigenous inhabitants of the Pacific islands the worm concerned is *Necator americanus*, but *Ancylostoma duodenale* has been introduced by Indian and other Asiatic immigrants. Percentages of infection in the population are given in various reports, but it is of little value to quote figures based upon methods of examination of very varying degrees of accuracy. In the Japanese mandated islands half the people are infected, in Guam infection is said to be increasing, in Papua and New Guinea it is almost universal, in the Solomons almost all persons are infected but the number of worms found in each case is said to be relatively small. In the New Hebrides infection is widespread and it is present in New Caledonia and the Loyalties. In Nauru about 90% of the people of the lagoon area harboured the worms in 1926, but in the foreshore areas only 41% of infections were found; in 1932 only one case was found and it is concluded that the infection had been almost eradicated by treatment or preventive measures. Hookworm infection is comparatively rare in the Gilberts though widespread in the Ellice islands. The difference has been attributed to the habits of defaecation, for whereas the people of the Gilberts have fear of magic and deposit their faeces below high water mark, the Ellice islanders have no such fear and pollute the ground widely. In Fiji infection in the wet zone (where soil moisture is favourable for development of hookworm embryos) was at one time as high as 90%; in the dry zone it was only about 40%. Recently these rates have been reduced by the measures taken to control the infection. In Uvea and Futuna low rates are reported, but it is noted that sanitation is bad. In Samoa and in Tonga infection is common but mild. In the Cook islands, Aitutaki has the worst reputation, but the condition is everywhere common. In the Hawaiian islands infection is fairly common but is usually light.

It may therefore be stated that, although hookworm infection is undoubtedly widespread, it is usually relatively light in the individual cases and does not cause much disability. It has, nevertheless, been regarded as a cause of the indolence and listlessness of the people of Samoa, the Ellice islands and the Tokelau group, and comparison

has been drawn between the vigour of the Gilbert islanders and the apathy of the Ellice islanders.

Other Intestinal Worms

Of the other intestinal worms none has any great importance. The round worm *Ascaris lumbricoides* is widely prevalent, but it has been stated that *Ascaris* infection is not found in the Tokelau group and the Ellice islands. *Tapeworm infection* is notably rare in the south Pacific except in immigrants who have brought infection with them, though it is found in Hawaii; infection with *Hymenolepis nana* is found in some islands. *Clonorchis* and *Fasciola* infections are reported from Hawaii and one case of *Paragonimus* infection has been seen in New Britain—this may perhaps be commoner than has been supposed in that area. *Trichinella* infection is present in rats and swine in Hawaii, and a number of human cases have been seen. *Strongyloides stercoralis* is found in Malekula in the New Hebrides.

Intestinal Diseases

Water-borne diseases are important throughout, but cholera has not recently been reported. *Bacillary dysentery* and *infantile diarrhoea* are responsible for many deaths in children and may occur in epidemic form, as, for instance, in Papua, Fiji, the Ellice islands and Samoa in the last twenty years. Usually the less severe Flexner type of dysentery bacillus is found, but in Samoa the severe Shiga form has been encountered. It is, perhaps, likely that Shiga infection will be found in islands which have been occupied by the Japanese, since it is common in Japan. *Amoebic dysentery* is present to a small extent in many islands, but its late effect, liver abscess, is not common. Infection in apparently healthy persons is more frequent than is usually suspected, and it may be contracted by immigrant white persons who are not scrupulous concerning precautions against using contaminated water or food. *Balantidial dysentery* has been reported from Samoa.

Fevers of the *typhoid group* are found in the Japanese mandated islands, New Guinea, New Caledonia, Fiji, Samoa, Tonga, the Cook islands, French Oceania, and doubtless elsewhere. They appear to be endemic and the indigenous peoples probably acquire immunity though at the expense of considerable mortality in the early years of life. Epidemics are not common, but immigrant white persons should take all precautions against these diseases, including that of protective inoculation. The typhoid fevers are usually transmitted

in food or drink contaminated with faecal material or through contact with a carrier of the causative bacilli; flies probably play an important part in transmission.

Nutrition and Nutritional Diseases

Most Melanesians and Polynesians take a varied diet, which is conducive to good nutrition. They have a variety of crops, and use forest leaves, roots and fruits. Pigs and hens are almost universal, but cattle as a rule are not kept. Polynesians usually live close to the sea and collect a great variety of fish, molluscs and other animal foods. With the advent of white men, there is a tendency to use tinned foods, the effect of which on nutrition cannot yet be assessed. In New Guinea taro, breadfruit, maize, bananas, sweet potatoes, sugar cane, sago, tapioca (manioc) and yams are largely eaten, with small quantities of animal fat and ground nuts. Pig flesh, fish, birds, and shellfish are also eaten, but, in the interior, sparingly.

In the Japanese mandated islands taro and tapioca are staple foods and these, with yams, sweet potatoes, fruits and vegetables form the main articles of diet throughout the south Pacific also. Pigs, though common, are usually only eaten at feasts; eggs of fowls and turtles are used to some extent; milk is not available on most islands. While there is no actual shortage of food, therefore, it is evident that the common diet is ill-balanced. It is said that tropical phagedaenic ulcer is specially common in sago eaters and rare in fish and taro eaters.

The diet of the Pacific islanders, like that of many other primitive peoples, contains too much carbohydrate and too little protein and fat. It is also deficient in vitamins. In New Guinea this deficiency is said to apply particularly to vitamins A and C. Shortage of vitamin B does not, apparently, occur to a serious extent, though in plantation labourers, who usually subsist on a diet which differs from that of village natives, shortage of this vitamin has led to outbreaks of *beriberi*. Infant beriberi has been reported from western Papua and is one of the causes of high infant mortality. *Scurvy*, indicating deficiency of vitamin C, is also seen in Papua and New Guinea, where it was known as 'New Guinea sore mouth', and certain eye conditions which suggest vitamin A deficiency have been noted. Incidentally, in some parts of Papua there is a shortage of iodine in the soil, indicated by the high incidence of *goitre*.

In the Solomons the main deficiency is of vitamin A, which has been held to be, in some part, responsible for the high incidence of

disease of the respiratory organs. Vitamin D is also lacking, but sunlight largely makes up for this. In French Oceania there is vitamin B1 deficiency among Chinese and Annamite labourers. In Nauru, in 1926 and 1936, there were serious outbreaks of infant beriberi, and this still caused, in 1940, eight out of the 34 deaths recorded. This very fatal condition is being prevented by the use of unfermented toddy (prepared from the spathe of the coconut). Unfermented toddy (*ekarawe*) is rich in vitamins A, B and D, and its use is encouraged for expectant mothers and infants. It is the use of the fermented product (*demani*) which is restricted in Nauru, and not of *ekarawe* as has sometimes been stated. Beriberi exists also in the Gilbert and Ellice islands. In Fiji a form of *epidemic dropsy* has been reported, but it is not clear if this is the same as the epidemic dropsy which occurs in India and which is due to poisoning from the use of mustard oil contaminated with the products of *Argemone mexicana*. In Tonga vitamins A and D are deficient, and there is a shortage of calcium, iron and iodine.

Poisonous fish are present in the waters around the Japanese mandated islands, the Ellice islands, Tonga and French Oceania; the fish concerned include the sea-perch, *Ephinephelus merra*, the eel *Anguilla mauritiana*, the parrot-wrasse *Pseudoscarus abacurus* and the sea-bream *Monotaxis grandoculis*. The symptoms of poisoning are nausea, vomiting, diarrhoea, and paralysis of the legs. Death is rare; it occurs only among strangers unfamiliar with local fish. The turtle *Chelonia imbricata* may be poisonous; 52 cases of poisoning, with 9 deaths, have been reported from Wooi on the north coast of New Guinea. Whether there has been a temporary alteration in the species to become poisonous, or whether a particular variety of the species is concerned, is not known. The symptoms of poisoning are characteristic.

It may here be noted that *undulant fever*, usually acquired by drinking milk from cattle or goats infected with the disease, occurs in the Hawaiian islands. It is not reported in the south Pacific except from Australia and New Zealand.

Depopulation

The depopulation which has occurred in many of the Pacific islands is a subject upon which a great deal has been written. Many factors, physical and psychological, appear to have a bearing on this matter; so far as health is concerned, however, it would be difficult to deny importance to the high infant mortality which is the general rule,

to the high death rate from tuberculosis during the years of human fertility, and to the known effect of venereal disease in causing sterility. Nevertheless, although depopulation was serious in the nineteenth century, it ceased in many island groups towards the end of that century, and population is now tending to increase. At present, depopulation is serious only in the New Hebrides, the Marquesas, and possibly in other groups of islands in eastern Polynesia. (For further details see Chapter XI, pp. 344–50.)

Medical Organization

The great medical problem of the Pacific islands is that of providing a medical service for the innumerable islands, far apart and having, in many cases, very small populations. The various governments each have their medical departments, in charge of European, American or Japanese personnel (as the case may be) who have normally been trained outside the Pacific islands. In many island groups missionaries from Europe, America, Australia and New Zealand also carry out medical work at varying levels of intensity. Grappling with medical problems in the Pacific has not been entirely a national affair; substantial assistance in funds and personnel has been given, for instance, by the Rockefeller Foundation for hookworm and yaws campaigns covering a number of island territories on an international basis.

In recent years there has been also a growing interest in attempting to enlist the aid of the native peoples themselves in the general health programmes, especially in providing a local personnel to assist in medical work. In British territories, for example, the policy, in addition to the provision of European personnel, is to train natives as medical men, and to this end a medical school has been instituted in Suva in Fiji, from which the first students graduated in 1889. By the end of 1936, 195 native medical practitioners had graduated. These men are drawn from certain British and American territories in the Pacific, and are given a course which lasts four years, and in which stress is laid on operative surgery, public health and preventive medicine (vol. III, p. 188). After graduation the men return to their own islands. Eventually there will probably be enough native medical practitioners to satisfy the needs of most of the island groups.

Hospitals and Staffs

Some idea of the present stage of development of medical services may be gained from the enumeration of hospitals, medical personnel, etc., in

the various territories given below. This aims at giving a general picture of the situation existing about 1939; in particular, it disregards changes due to the present war. Further details for some areas are given in the succeeding regional volumes of this Handbook.

Japanese Mandated Islands. Hospitals existed on Saipan, Yap, Koror (Palau), Truk, Angaur, Ponape, Kusaie and Jaluit. For these there were about 25 physicians. On Tinian and Rota private practitioners also held appointments as public physicians. There were about eight native physicians.

Guam. Until the Japanese occupation there was a naval hospital at Agaña and also the Susana hospital, with nine medical officers and one dentist.

New Guinea. In the Mandated Territory of New Guinea (excluding the Kieta District, in the Solomons) there were hospitals for Europeans at Rabaul, Kavieng, Madang, Salamaua, Lorengau and Aitape. Native hospitals existed at Rabaul, Gasmata, Talasea, Salamaua, Madang, Ambunti, Aitape, Lorengau, Kavieng and Namatanai. There was a laboratory at Rabaul. There were nine or ten government medical officers. At Vunaraima there was a mission doctor.

In the Territory of Papua there were hospitals at Port Moresby (for both Europeans and natives), Samarai, Salamo (in the D'Entrecasteaux group), and Hanuabada; there were clinical laboratories at Port Moresby and Samarai.

Solomon Islands. In the British Solomon Islands Protectorate government hospitals for Europeans and natives existed at Tulagi and Auki; small native hospitals existed at several other government stations. There were about ten hospitals maintained by missions or commercial companies, amongst the most important of which were those at Fauabu (Malaita), Biloa (Vella Lavella), and Ugi. There were two government medical officers, five or six medical men in the service of missions or commercial firms, and five native medical practitioners. In the Kieta District of the Territory of New Guinea there were hospitals at Kieta and Buka passage, the former being under a European medical officer.

The New Hebrides. There are two well-equipped hospitals at Vila, one maintained by the French administration (equipped with X-ray), the other subsidized by the British administration and controlled by the Presbyterian mission; there are smaller hospitals at Luganville (Espiritu Santo), Norsup (Malekula), and Lolowai (Omba), and two at Lenakel (Tana). In 1938 there were eight to ten fully-qualified doctors and two native medical practitioners in the group.

New Caledonia and the Loyalty Islands. There are two hospitals at Noumea and three smaller ones at Bourail, Canala, and Ponérihouen; at Thio and Ouaco are private hospitals. At Noumea there is a laboratory. On Ducos peninsula, near Noumea, there is a leper asylum for Europeans, and there are also several in the colony for natives. Qualified doctors number fifteen to twenty, the majority being government officers.

A government medical officer is stationed at Uvea (Wallis island), and the hospital under his charge also serves Futuna.

Gilbert and Ellice Islands. Before the outbreak of war with Japan, government hospitals existed on Tarawa (Gilberts), Funafuti (Ellice islands), and Ocean island; and there were about 25 simple 'island hospitals' elsewhere in the area. The British Phosphate Commissioners maintained hospitals on Ocean island for the three sections of the island's population. There were two government medical officers, two doctors employed by the Phosphate Commission, and ten native medical practitioners; the government maintained a motor vessel for medical work.

Nauru. On Nauru there were two hospitals, one maintained by the administration, the other by the British Phosphate Commissioners. There was also a segregation hospital and a clinic for lepers. The medical staff comprised several European doctors and nursing sisters and a number of Nauruans trained to assist in medical work.

Fiji. In 1938 there were between fifty and sixty hospitals and dispensaries in the colony. There were sixteen hospitals, exclusive of mission hospitals. The principal hospitals are at Suva (Colonial War Memorial Hospital), Lautoka, Lambasa and Levuka ; there is the central leper asylum at Makongai, a mental hospital and the Suva gaol hospital. There is also a hospital owned by the Colonial Sugar Refining Company, one owned by the Methodist mission, an Indian women's hospital at Mba, and several plantation hospitals. At Suva and Makongai there are laboratories, and at Suva is the Central Medical School from which, up to 1936, 195 natives had graduated. There were, in 1938, 21 medical officers, 66 native medical practitioners, and 7 Indian medical practitioners.

Samoa. In the Mandated Territory of Western Samoa there is a hospital at Apia, with branches at Tuasivi and Aleipata ; there are also small hospitals at Fangamalo, Sataua, Poutasi, Leulumoenga, Sa'anapu and Fangaloa. In 1940, 2,060 patients were admitted and over 60,000 out-patients treated. In 1941 the medical staff consisted of three medical officers, a dentist and a bacteriologist, ten nursing sisters, sixteen native medical practitioners and subordinate staff.

In American Samoa there is a naval hospital for service personnel and a hospital for Samoans ; there are four out-lying dispensaries and a well-equipped laboratory. Three naval medical officers and a dentist are stationed in the territory.

Tonga. There are three European medical officers and seven Tongan medical practitioners. There is a hospital at Nuku'alofa (which has a portable X-ray apparatus) ; there are smaller hospitals on Ha'apai and Vava'u, and dispensaries on Niuatoputapu and Niuafo'ou.

Cook Islands. There is a hospital at Avarua, on Rarotonga, with accommodation for 34 natives and 4 Europeans ; the Chief Medical Officer is at this hospital, and he has an assistant who travels.

French Oceania. Hospitals exist at Papeete and Taravao, in Tahiti ; Uturoa, in Raiatea ; Makatea, in the Tuamotu archipelago ; and Atuona, on Hivaoa, in the Marquesas. There are small dispensaries in other areas, and out-lying regions are visited from time to time by medical officers. Leper asylums have been established at Orofara (in Tahiti), at Reao (in the Tuamotu archipelago), and in the Marquesas.

Hawaiian Islands. Medical facilities in the Hawaiian islands are well developed. There are 450 physicians in the islands and about 45 hospitals, some of which are fully up to accepted standards on the American mainland. Details are given in the *American Medical Directory*, 1940.

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Chapter IX

HISTORY, 1513-1843

THE AGE OF THE EXPLORERS, 1513-1779

In the fifteenth century European navigators conquered the Atlantic. The voyages of the Portuguese down the African coast had been followed before the end of the century by two feats of discovery which were to transform the whole Western World. In 1498 Vasco da Gama reached India by way of the Cape of Good Hope; and six years earlier Christopher Columbus, setting sail from Spain, had arrived at the previously unknown lands which bounded the Atlantic upon its western edge. Columbus believed that he had reached the outskirts of China; but within a few years it began to be perceived that, instead, a new continent had been discovered. As a consequence, it became evident that another ocean, as yet unvisited by Europeans, must stretch between the new America and the old Asia. That ocean was first seen in 1513 from the isthmus of Panama by the Spaniard Nuñez de Balboa, who named it the South Sea.

The task which Columbus had essayed, of reaching the East by sailing west, was now demonstrably more difficult than had been at first believed; but, in the temper of the age, men were certain to persist in the quest. Already much was known of the resources of the East. The steady flow of trade which had existed in Roman times had never entirely dried up, though for some centuries it had been little more than a trickle. In the late thirteenth and early fourteenth centuries, political conditions in Asia had for a time made it possible for Europeans to travel as far east as China. From Marco Polo's vivid descriptions of what he saw and of the rich lands of which he was told—in the vicinity of Malaya and Java and further south—later commentators formed the conception of a great continent. From this, and from the speculations of geographers, *Terra Australis*

Incognita emerged—an immense land covering much of the unknown parts of the southern half of the world. Thus, Europeans had two motives for venturing upon the waters of the Pacific: they wished to cross it in order to reach the known riches of China and the Indies; and they wished to find the unknown continent of *Terra Australis*, whose wealth might perchance exceed that of any country yet known, just as the riches of Mexico and Peru had exceeded those of Columbus's Hispaniola, or as the trade of the Moluccas was expected to exceed that of the ports of the Indian ocean.

Men's desires set the pace of discovery, their technical competence imposed limits upon their achievement. During most of the Middle Ages maritime enterprise was restricted by the poor quality and small size of the ships—little bigger than fishing smacks—and by the lack of any adequate method of ascertaining position when out of sight of land. In the thirteenth and fourteenth centuries, however, improvements were made. The compass began to come into general use; the astronomer's cross-staff and astrolabe were adapted and improved for use in fixing latitudes; and the old Pilot-Books, Portolans or Rutters, handed down from Greek or Phoenician times, were improved and brought into more general use. The Portuguese voyages into unknown waters in the early part of the fifteenth century at last made necessary the systematic study of navigation. Prince Henry the Navigator, the sponsor of Portuguese maritime activity, recognized the need and founded an academy for the purpose at Sagres and a chair of astronomy in the university at Lisbon. Thus mathematicians and astronomers, geographers and explorers, were brought together to study the problems which the new voyages had created. When the Equator was crossed (about 1471) the old method of fixing latitudes by the Stella Maris became insufficient and with the consequent development of a simple system for obtaining it by a noon observation of the sun the way was opened for mariners to sail with equal safety in either hemisphere. In the same period considerable improvements had also been made in the building of ships. But though, by the time the Pacific was discovered early in the sixteenth century, so much had been learnt, knowledge and skill were still no more than barely sufficient to permit the most intrepid of explorers to struggle across its vast distances. Though ships were far better than they had been when mariners were content to hug the coasts of Europe and northern Africa, they were still poor enough by later standards. And though latitude could be ascertained with accuracy there was

still no practical method of fixing longitude, nor was this problem completely solved until the development of the chronometer in the eighteenth century: mariners could do little more than obtain a dead reckoning of the distance run, and so inaccurate was this procedure that, in the words of an English writer of 1579, many preferred to ‘gesse whereabouts they be touching’.

Many centuries before the era of European maritime exploration began the Pacific had, however, been entered by large numbers of voyagers. The ancestors of the Melanesian, Micronesian and Polynesian peoples had travelled eastwards from Asia and reached the islands which became their permanent homes. Among the Polynesians had been great navigators, who, by their knowledge of the heavens, of winds and seas and of the migrations of birds, had passed back and forth across wide stretches of empty ocean between central Polynesia and the outlying groups of Hawaii and New Zealand. But by the fifteenth century such voyages were nearly over: when Europeans entered the Pacific they found the islands inhabited by a non-migratory population (pp. 370-8).

The Quest of the Spaniards (Fig. 79)

In 1494, by the Treaty of Tordesillas, Spain and Portugal had divided the unknown world between them by a line drawn 370 leagues west of the Cape Verde islands. All lands to the east of this line were to be considered within the sphere of the Portuguese, while those to the west were to fall to Spain. Thus, if the Spaniards were to make good their claim to the riches of the Pacific and to obtain a foothold in the Moluccas, they must approach these regions by sailing westwards beyond America. The problem was solved for Spain by Ferdinand Magellan, born himself a Portuguese but now a Spanish subject, when he found the longed-for passage through the American continent and entered the South Sea by the strait which now bears his name.

Magellan had heard in his childhood at the court of Portugal the stories told by explorers returning from the east and from the west; in his youth he had sailed himself to the East with Almeida and spent seven years there learning of its possibilities, and from his friend Francisco Serrão, who travelled beyond the regions of Portuguese influence and settled in the island of Ternate, he heard of riches greater still. After returning to Europe he fell into an undeserved disgrace at court. In his idleness he gave his time more and more to thoughts of the East and to the study of geography and navigation.

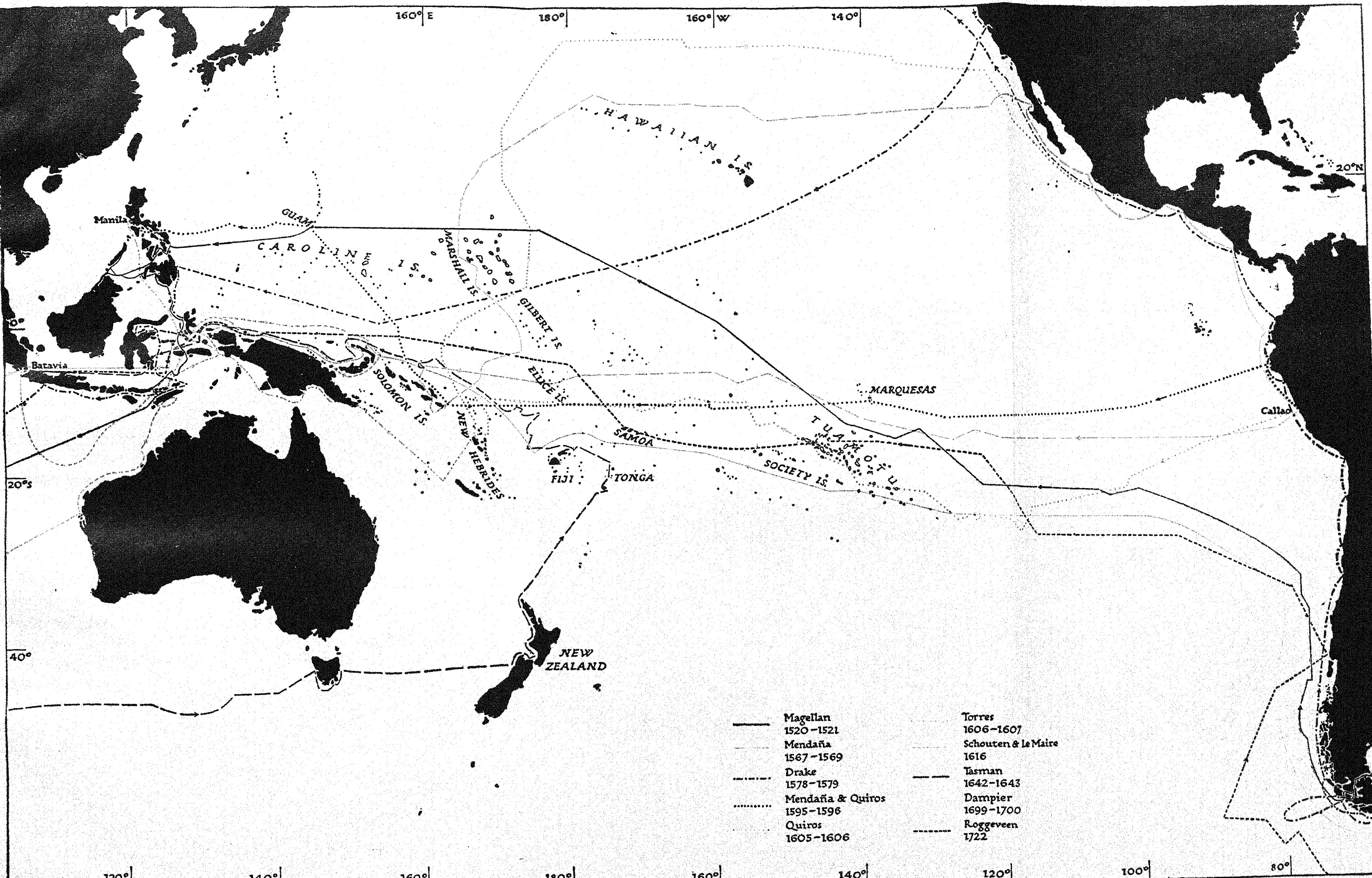


Fig. 79. Exploration of the Pacific (Magellan to Roggeveen)

Based on: (1) J. C. Beaglehole, *The Exploration of the Pacific*, maps 1 and 2 (London, 1934); (2) original narratives of the explorers (see Bibliographical Note, pp. 287-8).

In 1517 he formally changed his nationality, and travelled to Seville with his companion Ruy Faleiro, astrologer and authority on navigation. They laid before the King their plans for a voyage to the Spice islands by way of a passage through South America, which they felt confident must exist, and a crossing of the still untraversed South Sea.

Royal approval was obtained, and by September 1519 all was ready: heavily laden and provided with trade—looking-glasses and beads, knives and fish-hooks, and '20,000 bells'—the five ships sailed out of the Guadalquivir. All through the southern summer the South American coast was searched for a passage but without avail. It became necessary to winter in America before continuing the voyage. In the spring the ships sailed south again. On 21 October the land fell away sharply. Two ships were sent in to investigate. They returned with news that the channel seemed to have no end, and that there seemed to be a current flowing westward. The fleet entered, and after a difficult passage they came at length to a long cape, called by them the Cape of Desire; beyond it they saw open sea. But now there occurred a delay, for in the passage of the straits the *S. Antonio*, the largest ship in the fleet, had been lost sight of. They searched for her, and ceased only when an astrologer told them, truly as it proved, that she had deserted. Another ship had been lost in an accident while they were wintering, so that now there were but three; and a large part of their provisions had been lost in the defection of the *S. Antonio*. In spite of their misfortunes it was decided to go on; and on 28 November 1520 they entered the South Sea, bound for the Moluccas, whose latitude they roughly knew, across an ocean which no European had yet sailed.

Magellan sailed north-west before the trade winds. The ocean was so tranquil that he named it the Pacific. But ahead of him lay worse than storms. The water became so bad that the men held their noses as they drank it. Biscuit, befouled and reduced to powder by rats, and sawdust became their principal foods. Even the hides of the rigging were cut and dragged overboard until they were soft, and then broiled for eating. With the coming of scurvy the men's gums swelled until they could not eat at all. Many died. And tragically, as they half drifted beneath the rays of the beating tropic sun, their course seems to have taken them many times just out of sight of islands where relief could have been obtained. Towards the end of January, they sighted a tree-covered island, but there was no anchorage and it seemed to be ininhabited. It was not until 6 March

that they saw land again, and this time there were canoes making towards them. It was the island of Guam. After 98 days the long crossing was over. In a few days the fruit and fresh water which the island provided considerably restored the health of the men, and they set out again. A week later they came again to islands—Samar and Leyte; they were in the group which the Emperor Charles V later named the Philippines. They anchored at Limasawa, where fruit, fish and palm wine were available in plenty, and then moved on to Cebu, whose rajah accepted a treaty of friendship with Spain and, with between two and three thousand of his subjects, was received into the Catholic church. Magellan was jubilant: his own fortunes seemed secure; his King and his God were being served. But in his jubilation he made his one false step; to prove the virtues of his religion and the greatness of his race he offered to subdue the people of a rebellious islet off the coast for his friend the rajah. The Spaniards were easily repulsed; Magellan himself, foremost in the fight, was beaten to the ground; and so he died.

After a voyage of a year and seven months, 'always in search of Maluco', Magellan had brought his men to the edge of known seas. The expedition eventually reached Tidore, its destination; and at last, on 8 September 1522, one ship, the *Victoria*, anchored again at Seville. Of her company eighteen still lived; these men were the first to have circumnavigated the world. Alike in the vision which had inspired it and the resolution with which it had been carried out, Magellan's achievement was unique in its age. He had proved that men could sail westward beyond America; he had revealed the size of the Pacific and opened the way for almost limitless further exploration; and in the completion of the voyage philosophers had been given the reality of men sailing into the west and returning from the east.

A second expedition was despatched to the Pacific by way of Magellan's straits in 1525. Receiving word of it, Cortes, the conqueror of Mexico, sent out a force of his own to lend it support. Henceforth Spanish knowledge of the Pacific was to be built up entirely by ships sailing out of the ports of Mexico and Peru: Magellan's route exacted too heavy a price upon human endurance. Expeditions continued to be despatched across the Pacific; and in 1565 Miguel de Legaspi established a settlement in the Philippines. In the same year one of Legaspi's captains, Urdaneta, solved the problem which had baffled all previous voyagers, of returning across the Pacific to America. Urdaneta sailed northwards into regions

hitherto unvisited and picked up westerly winds like those of the North Atlantic. This discovery gave the settlement at Manila an added importance: it became an entrepôt for goods from China, Japan and the Indies, which were reshipped across the north Pacific to Mexico.

The colonization of the Philippines had a limited importance in the history of the Pacific. It led to the gradual penetration of the islands of Micronesia. But the ships passing back and forth between Manila and Acapulco traversed mainly empty seas. The interest of explorers centred in the southern half of the ocean; their primary object was the discovery of *Terra Australis Incognita*. The first Spanish expedition to search for the continent was that led by Alvaro de Mendaña which sailed from Callao in 1567. The land which he was to discover was reputed to lie at about 600 leagues from the Peruvian coast; the ships were therefore victualled for only that distance. But the expedition had sailed westward for two and a half months, passing only small islands, before a long and high coast came in sight at last on 7 February 1568. This, it was felt must certainly be the continent. They named the land Santa Ysabel, for they had sailed on her feast day, and she had been their patron throughout the voyage. Friendly relations were established with the natives, black and frizzly haired, who were delighted with the coloured cloth and beads the Spaniards brought them. But soon it was found that, fertile though the land was, it did not produce enough for the inhabitants to continue supplying the visitors with food. For mere self-preservation stealing had to be resorted to; and inevitably hostilities resulted. Meanwhile, it had been discovered to Mendaña's disappointment that the land was only an island; and the natives told of others not far away. These islands were explored—Guadalcanal, Malaita, Ulawa, and San Cristobal: they were found to be thickly populated, fertile and well-watered. It was thought that there were signs of gold and, although the metal itself eluded them, the group was on this account named the Solomon islands.

Six months thus passed away in the Solomons, but early in August it was decided, because of illness, to remain no longer. Mendaña now wished to sail south-west, in the dual hope of making further discoveries and of finding winds to carry them to Chile. The pilots insisted that the only safe course was to make north-east for Mexico or California. Out of this conflict an unsatisfactory compromise was reached: the pilots were to have their way when the winds favoured them, and Mendaña was to have his when they

favoured him. After a voyage of four months, beset by storms and scurvy, they sighted the coast of Lower California on 19 December. It was another nine months before they finally arrived again at Callao. ' In my opinion ', a Peruvian official wrote of the Solomons, ' . . . they were of little importance . . . for in the course of these discoveries they found no specimens of spices, nor of gold and silver, nor of merchandise, nor any other source of profit, and all the people were naked savages '. Yet in the taverns and on the quays of the sea-ports of the Pacific coast stories passed from mouth to mouth of the fabulous wealth of Mendaña's Land of Ophir; and Mendaña himself made it the purpose of his life to return there to found a colony. But, often sought for, the Solomons remained unvisited again for two hundred years. So faulty was the method of reckoning longitude that Mendaña and his pilots had underestimated their distance from the American coast by no less than two thousand miles.

The discovery of the Solomon islands soon became known in England; and men there thought, as Drake's nephew later wrote, that, though Spain might claim America, ' the maine Ocean by right is the Lord's alone, and by nature left free for all men to deale withall, as very sufficient for all mens use, and large enough for all mens industry '. Several English projects for Pacific adventure and exploration culminated in that of Francis Drake to discover the southern continent and the North-west Passage. But Anglo-Spanish relations became increasingly bad in the period before Drake sailed; and the voyage was changed, with Queen Elizabeth's approval, into a treasure raid. The return of the *Golden Hind* to Plymouth in September 1580 at once transformed English interest in the Pacific and presaged the end of the Spanish era of exploration: Englishmen's minds were dazzled by the prospects of plunder, while Spanish officials were forced to consider whether any new discoveries might not simply increase the activities and the opportunities of their English enemies.

But two more great voyages were still to be made before the fading of the heroic age of Spain. In 1595 Mendaña left Callao again with four ships carrying settlers and materials for the foundation of a colony. The first land they sighted was taken to be the Solomons until it was discovered that the people were fair and clear skinned. Mendaña named the new group ' Las Marquesas de Mendoza ' (now known as the Marquesas). Quiros, the chief pilot, writes of the excellent water, the luxuriant woods, the fine climate; he describes

forty paddlers, and the women, graceful and nearly white, some of them more beautiful than the women of Lima who were famed for their beauty. Despite the injunctions of Mendaña and his officers, the Spaniards steadily killed these friendly people, for, as one soldier said, 'it was his diligence to kill because he liked to kill'. At the end of a week they sailed away leaving at least two hundred dead and three crosses erected to the glory of God.

Several times as they sailed on they passed small islands, and in a month they came again to high land, a large volcanic island, tree-covered and very beautiful. Mendaña named it Santa Cruz. The natives were frizzly haired and dark skinned, but they did not understand the language of the Solomons. Almost at once hostilities broke out between them and the Spaniards. Mendaña moved the ships to another bay to which he gave the name Graciosa, and here, on a fertile plain, he decided to plant a settlement. And then sickness came: man after man went down with it; Mendaña himself died on 18 October 1595. A month later the ships sailed, leaving Santa Cruz 'in the claws of the devil'. One of the ships had been lost on the outward voyage; two more went down in stormy weather after leaving the island; the fourth finally struggled into Manila, racked by disease and split by plots among those on board.

Pedro Fernandez de Quiros, the chief pilot on this voyage, now took upon himself the mission which had been Mendaña's: and in December 1605 he sailed again from Callao in search of the southern continent. Between 26 January and 8 February 1606, a number of low-lying islands were seen—Ducie, Henderson, as well as others on the south-western fringe of the Tuamotu archipelago. Several other islands were passed as they sailed on towards the west. These included one (Swains island) where the people were so fair and graceful that Quiros named it Gente Hermosa—the Island of Beautiful People. To Quiros the voyage was a crusade to extend the bounds of Christendom. As the weeks passed his mysticism took an ever increasing hold upon him. Towards the end of April he gave the order to 'put the ships' heads where they like, for God will guide them as may be right'. A few days later they found themselves in the midst of high lands which rose until they were lost in the clouds. This was the continent—could Quiros doubt it? —which had been sought for by so many. He marvelled that it should be he for whom God had reserved so great a discovery. A fortnight later he named it 'Austrialia del Espiritu Santo': it was the island now known as Espiritu Santo in the New Hebrides.

Exploration showed the land to be rich and beautiful, to have fertile plains on which cities might be built, a fine river and gentle wooded hills. Only man was vile: they could not make peace with the natives. But Quiros could not allow such difficulties to interfere with a plan so grand as his. With stirring ceremonial—music and processions and much prayer—possession was taken of the land, and the foundation of the city of New Jerusalem was proclaimed. Elaborate machinery for the government of a province was instituted. Then, quite suddenly, after they had been there three weeks, Quiros announced that Austrialia del Espiritu Santo was not to be settled at all. They were to sail next day.

The ships lost one another. Quiros sailed north towards the latitude of Guam, undecided what to do. Then he made for Mexico, where he arrived in November 1606, eleven months from his departure from Peru. The other ships, under Don Diego de Prado and the able Luis Vaez de Torres, sailed north-west towards Manila and made a discovery of capital importance. Unable to weather the east point of New Guinea, they sailed west along that country's hitherto unknown south coast, thus proving that it was an island. But Torres' discovery was kept secret by the Spaniards, and it was not until the latter part of the eighteenth century that the existence of a strait connecting the Coral and Arafura seas was generally known to navigators. The Spanish authorities themselves had no desire to pursue further the exploration of the Pacific. They knew truly that all their energies would be absorbed in holding and developing the lands which they already possessed. Quiros agitated ceaselessly to be sent out again, but he met with no success. With his death in 1614 an age in the history of the Pacific was drawn to a close.

The Seventeenth Century

In the seventeenth century the principal contributions to Pacific exploration were made by the Dutch. In 1580 Philip II of Spain had forcibly occupied Portugal, to the throne of which he possessed a claim. A year later the Netherlands had declared their independence of him, and following this bold act they had successfully invaded the Portuguese sphere in the Indies. So rich was the trade which they soon built up for themselves in the Moluccas, in Java, and on the mainland of India that exploration was at first unnecessary.

Their earliest discoveries were mainly incidental to their trade. In 1611 they began to use a new way east. After passing the Cape of Good Hope, instead of following the coast of Africa, they sailed

eastward before the constant winds of the 'roaring forties' until they reached the longitude of Java and then turned north. But, the method of fixing longitude being so primitive, they sometimes sailed too far, and thus came upon land. In this way a picture of the west and part of the north and south coasts of Australia, or New Holland as they named it, was gradually built up. In size New Holland was a continent, but it was not *Terra Australis Incognita*; for that fabled land was populous and rich, while this was barren and peopled only sparsely by a race of primitive nomads. From time to time, however, officials of the Dutch East India Company convinced themselves that so long a coast and so large a land could not be wholly worthless; and expeditions were sent out from Java to continue the exploration which had been almost involuntarily begun.

The first great Dutch voyage, however, was made not by the agents of the East India Company, but by those of a rival syndicate which had been given permission by the government to trade in parts of the company's territories provided its ships did not enter the Eastern Seas by way of the Cape of Good Hope or Magellan's straits. In pursuance of this project Jacob le Maire and Willem Corneliszoon Schouten sailed from Hoorn in May 1615. They entered the Pacific by sailing round the south of Tierra del Fuego, where they named the southernmost point of land cape Hoorn. Like previous voyagers they hoped to find the southern continent. At the end of April 1616 they sighted the adjacent islands of Futuna and Alofi, where they spent several weeks and to which they gave the name Hoorn islands. From this point they sailed north-west so as to make the north coast of New Guinea. Several other minor discoveries were made—'Het groene Eylant' (Nissan) and 'S. Jans Eylant' (?Tauu) in the northern Solomons, and the Schouten islands off the north of New Guinea. From New Guinea they sailed through known seas to Batavia. Drake, nearly forty years before, had proved the insularity of Tierra del Fuego, but the fact had not become widely known, and the government of the Indies refused to believe their story of a new passage into the Pacific and confiscated their ship and their goods for an infringement of its charter.

Only ten years had passed between the voyage of Quiros and that of Schouten and Le Maire. But they belonged to different ages. The boundless hope of Quiros and, equally, the lack of discipline among his followers, were typical of Spanish activity in the Pacific. The voyage of Schouten and Le Maire, on the contrary, was remarkable for its orderliness. In this it was characteristic of the work of

all the Dutch navigators and particularly of that of Abel Janszoon Tasman, the ablest among them. But Tasman, like the other navigators sent out by the Dutch East India Company on voyages of exploration, merely executed plans conceived by others. His voyages were sponsored by Anthony van Diemen, who had become Governor-General at Batavia in 1636. During his first years of office Van Diemen sent out several exploring expeditions, and Tasman was among the pilots employed. Early in 1642 a voyage more ambitious than any which he had sponsored previously was planned. Tasman was given the command. He was instructed to proceed to Mauritius there to take on refreshments, then to sail south to 52° or 54° before turning eastward and running in that latitude until land was sighted or until he had found a new southern route to Chile. He was then, if possible, to turn north-west and sail before the trade wind until he came to the Solomons, which he was to explore ; and from the Solomons he was to return to Java.

In August 1642 Tasman sailed from Batavia with two ships, the *Heemskerck* and *Zeehaen*, and in October he left Mauritius. Early in November the ships were in latitude 49° 04′ s, but the weather was bad and the high seas from the south-west argued the absence of any continent in that quarter. They returned to 40°. Running steadily eastward they sighted high land on 24 November and named it Anthony van Diemen's land. They went ashore and found the land good and well-wooded, with evidence of being inhabited. They followed the coast until it fell away to the west, when they turned east once again towards the supposed longitude of the Solomons. On 13 December, towards noon, high land was seen again in the south-east. Forested hills rose beyond the shore to lose themselves in the clouds. It was the west coast of the South Island of New Zealand. They followed the coast northward for several days until it fell away abruptly amid sand dunes. Beyond the cape they found anchorage. Here natives came out to gaze upon them. All went well until, quite without warning, a boat travelling between the two ships was rammed by a canoe. Three Europeans were killed and another mortally wounded. Tasman put at once to sea. For a week he was held in the treacherous winds and tides of Cook strait which he thought might be either a strait or a bay. Then he turned north and watched the surf-beaten coast until at last it fell away beyond a point which he named cape Maria van Diemen, after the Governor-General's wife.

On 4 January 1643 Tasman left New Zealand. He thought (or

hoped) that it was part of the southern continent and that it stretched south-east to join land which Schouten and Le Maire had discovered near cape Horn. If this were so, the way to Chile was open, and he had accomplished a major part of his task. To verify the latter part of this supposition, it was proposed to sail further east in a more northerly latitude. But the winds were against them, and they sailed north-west. On 19 January they came to Tongatapu, which they named Amsterdam island. Tasman was as favourably impressed as Cook was to be over a century later. 'It was all peace and amity here', he wrote; and they remained for several days bartering for hogs and fruit, which were obtained in abundance. Then, on the 25th, they discovered Nomuka, and named it Rotterdam. Here again they stopped to trade. Continuing towards the west they passed through the fringes of the Fiji group. Then, changing their course to north-west to avoid the dangers of a possible unknown lee-shore, they came, on 22 March, to a group of islets which was recognized as one which had been discovered by Le Maire; Tasman named it Ontong Java. From there they followed Le Maire's route to New Guinea and in due course arrived at Batavia.

Looking back upon Tasman's voyage it is impossible not to see that it prepared the way for the later explorers, who in the following 150 years laid bare the main outlines of the ocean and the lands which it contained. But the officials at Batavia, lamenting its failure to reveal any likely fields for the development of trade, were bitterly disappointed at the result. They were determined to continue the work of exploration, but after sending Tasman and Visscher, who had been his pilot major, on a voyage to the north coast of New Holland they decided to engage 'more vigilant and courageous persons than had hitherto been employed in this service'. But the directors in Holland were impressed neither by Tasman's achievements nor by the prospects of further voyages. Like the Spaniards before them, the Dutch were becoming conscious of the limits of their power and the rising ambitions of hostile nations. They retired from the work of systematic exploration; but, unlike the Spaniards, they made no attempt to hide from the world the knowledge which their explorers had gained.

The Circumnavigators (Fig. 80)

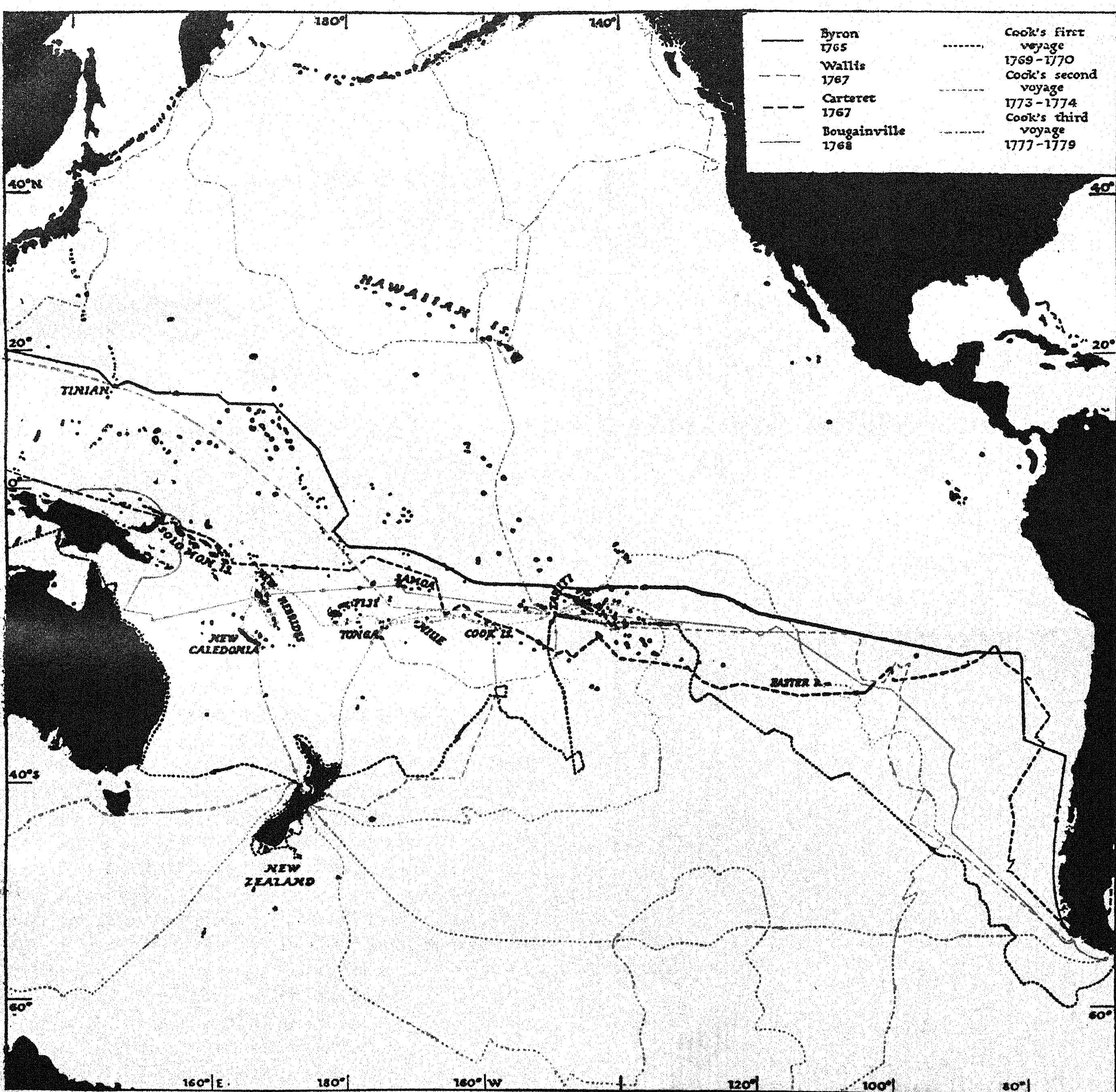
The explorers of the sixteenth century had desired to extend the boundaries of empire and of Christendom; those of the seventeenth had been concerned first of all with trade. It was to be typical of the

eighteenth century that, while it forgot neither trade nor empire, it added to them the interest and the attitude of science. But before the seventeenth century ended one man, working with the old and inferior tools of his time, applied to discovery the dispassionate mind of the later scientists. That man was William Dampier. His only discovery was the strait, now called Dampier passage, which separates New Britain from New Guinea. His true importance was as a writer. He described his voyages, the men and the lands he had seen, in clear and vigorous language. His work served as a model to future navigators and naturalists; and—even more important—he made the world of his own day conscious of the South Seas, of their resources and of the task of exploration still waiting to be done. The immediate result, however, was not further exploration but the increased study of geography and of the history of exploration.

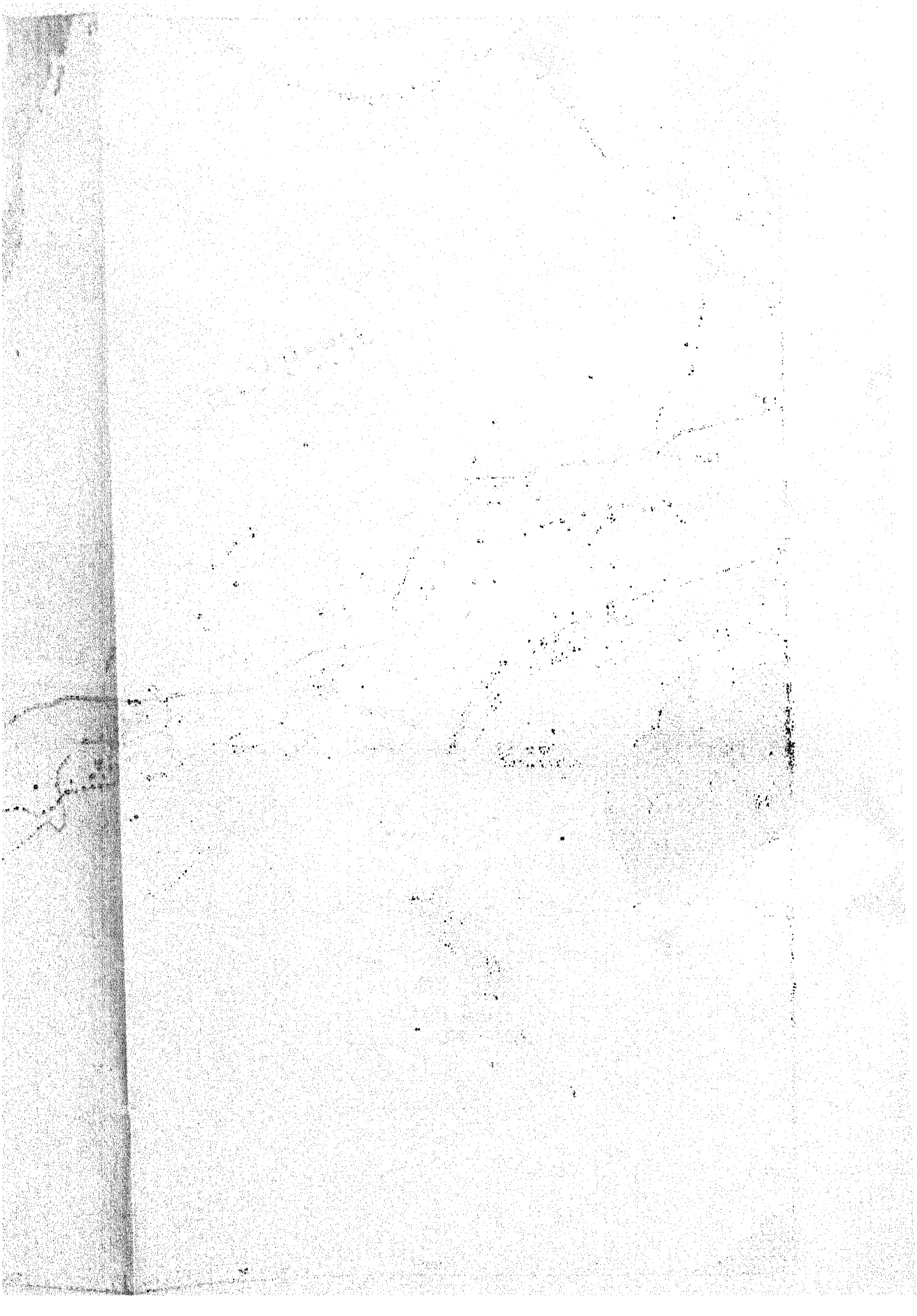
In the first half of the eighteenth century a number of English naval and privateering expeditions entered the Pacific. Several of them—especially the voyages round the world of Woodes Rogers, in 1708, and of Anson, in 1741–4—were notable achievements in their way; but they added little or nothing to geographical knowledge. The one important voyage during the half-century was Dutch, organized however not by the East, but by the West, India Company: Jacob Roggeveen entered the Pacific in March 1722 and sailed north-west in search of the southern continent; he discovered Easter island, several islands in the northern part of the Tuamotu archipelago, and the Samoa group; he arrived at Batavia in October.

After the close of the Seven Years' War in 1763 exploration was resumed by Britain and France on an impressive scale. Voyages of circumnavigation were promoted. The first was that sent out by the British Admiralty under Commodore John Byron. Byron entered the Pacific by the Straits of Magellan in April 1765. His instructions then required him to sail north to California, revive the claim to Drake's New Albion, and search the coast for a passage eastward to Hudson's bay. But his crew were sickly, and he determined instead to sail north-west before the trade wind in the hope of rediscovering the Solomons. In fact, he added only a few small islands to the map. He reached the Downs again in March 1766.

Three months after Byron's return the Admiralty sent out two other officers, Samuel Wallis and Philip Carteret, to search for the southern continent. After a long struggle with adverse winds the two ships passed out of the Straits of Magellan in April 1767 and immediately lost one another in fog and a rising sea. From that



Byron 1765
Wallis 1767
Carteret 1767
Bougainville 1768
Cook's first voyage 1769-1770
Cook's second voyage 1773-1774
Cook's third voyage 1777-1779
180°
140°
40°N
40°
20°
HAWAIIAN IS.
TINIAN
SOLOMON IS.
NEW HEBRIDES
NEW CALEDONIA
FIJI
TONGA
SAMOA
NIUE
COOK IS.
TAHITI
EASTER I.
NEW ZEALAND
40°S
60°
160°E
160°W
120°
100°
80°



point they pursued their voyages separately. Early in June Wallis came to the southern fringe of the Tuamotu archipelago and continued westward among low atolls. On the 18th high land was seen, densely wooded. It was Tahiti. Next morning hundreds of canoes came out to the ship, which followed the coast until, at the bay of Matavai, a harbour was found. Wallis landed, took possession of the island, and named it King George III's island. The friendship of the natives was soon completely gained; ample supplies of pigs, fowls and fruit were provided; and the Europeans moved about freely on shore. The ability of the people and the beauty of their island were admired almost as much as their unlimited hospitality was enjoyed. But as was to be found by later navigators—especially by the unfortunate Bligh—the effect of Tahiti upon naval discipline threatened to become disastrous. Wallis discovered that his men had begun to draw iron and copper nails out of the ship to buy the favours of the women. At the end of a month's stay he was relieved to put to sea once more. He sailed again towards the west and reached England again in May 1768.

Meanwhile, Carteret, in a worn-out and ill-equipped ship, had set out on his own to cross the Pacific. With greater resolution than was shown by Wallis, he kept to a more southerly course than any previous voyager. In these stormier and colder seas the southern continent would be found if it existed at all. Carteret sailed beyond the coasts of lands which geographers had boldly laid down, discovering only a small high island which he named after the man who first sighted it—Pitcairn. With his ship in desperate condition he kept on his course until he came to Mendaña's island of Santa Cruz, where he was able to make repairs. Then, sailing on, he rediscovered the Solomons, but failed to recognize their identity with the islands of which Mendaña had told. One more important discovery was still to be made: he found that Dampier's New Britain was, in reality, two islands divided by a strait; he named the northern one New Ireland. From then on the voyage was a struggle to keep the ship afloat, which ended, contrary to reasonable expectations, in Carteret's bringing her finally home to Spithead in March 1769.

As Carteret was slowly sailing from Cape Town to England, on the last stage of his voyage, he was hailed by name by a French ship which overtook him. Her commander was Louis Antoine de Bougainville, who also was returning from a voyage of exploration in the Pacific. Bougainville had entered the Pacific in January 1768. Like Carteret, he had sailed north-west in southerly latitudes and so

pushed back the limits of the southern continent. Then he had come to Tahiti, nine months after Wallis had left it. From Tahiti he had gone to Samoa, and from Samoa to Espiritu Santo, the first to disturb the solitude of the New Hebrides since Quiros more than a century and a half before. He had then continued westward undaunted by fears of a lee shore, until he reached the barrier reef off the eastern coast of Australia. He was on the verge of discoveries yet greater. But supplies were low and the ships had been long at sea. He therefore made for the East Indies. In March 1769 he anchored at St Malo, to tell of a voyage more distinguished than any yet made in the eighteenth century, and to publish a journal which did much to create in France the cult of the noble savage.

The Achievement of Cook

Since the voyages of Mendaña in the sixteenth century explorers had been disappointed in their search for the southern continent. A few, it is true, had discovered islands whose insularity still remained unproven; but more had found the seas continuing to roll up unbrokenly from the south where they had confidently expected land. The majority of eighteenth-century cartographers showed the Pacific as a vast expanse of ocean, broken only by small groups of islands. Yet the continental hypothesis had still not been destroyed. As late as 1769 Alexander Dalrymple, a man of experience and learning, published the most audacious of all statements concerning the unknown land. He believed that it stretched north-west from cape Horn, was greater in extent than all civilized Asia, possessed a population of about fifty millions, and offered unlimited possibilities for trade (Fig. 81).

But in the summer of 1768 there had sailed from England upon the first of his great voyages the man who within seven years destroyed utterly the belief in *Terra Australis Incognita* and before his death gave to the map of the Pacific something like its modern form. James Cook had been given the command of H.M. barque *Endeavour* for a voyage whose twin objectives were the observation of the transit of Venus at Tahiti and the continuation of the work of exploration which had been begun by the despatch of Byron, Wallis and Carteret. He entered the Pacific by cape Horn in December 1768 and reached Tahiti in April 1769. Three years before Cook sailed John Harrison had been awarded £10,000 on the successful trial of his chronometer, which made more exact and immensely simplified the fixing of longitude. But in 1768 the instrument was still in the experimental

stage, and Cook was not provided with one. He had found Tahiti by sailing into its known latitude and running west in it until he came to the island. In all his surveying on this voyage he used for fixing longitude the old and complicated method of taking lunars, supplemented by the observation of the transit of Venus at Tahiti and of a

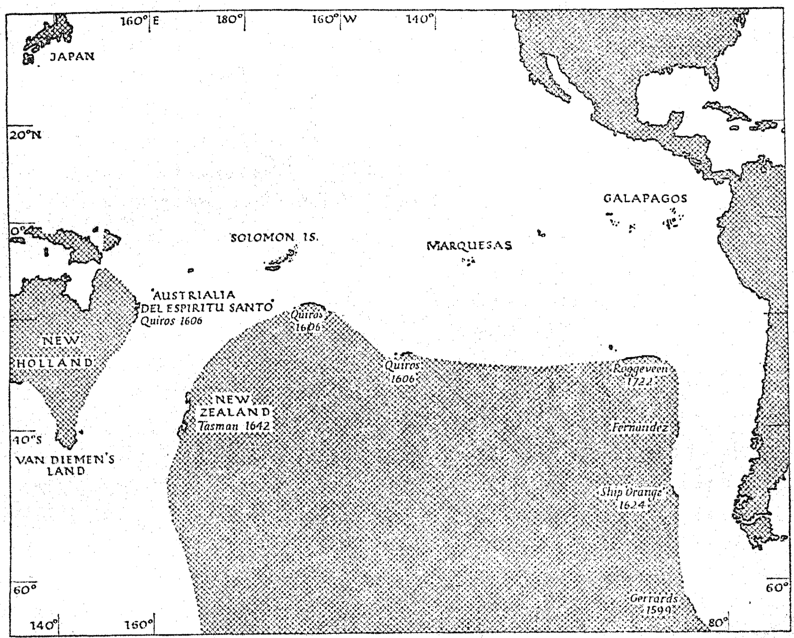


Fig. 81. The southern continent

This map illustrates the hypothesis put forward in 1767 by Alexander Dalrymple as to the extent of the supposed southern continent. Dalrymple argued that the isolated discoveries, or believed discoveries, of land shown here indicated the existence of a continuous coastline roughly approximating to the edge of the shaded area. The coasts of the countries bounding the Pacific have been taken from Sr. Robert de Vaugondy's chart of the Pacific ocean of 1756. (The relatively accurate delineation of the American coast shows the advanced state of Spanish surveys.) Based on: (1) (Alexander Dalrymple), *An Account of the Discoveries made in the South Pacifick Ocean, Previous to 1746, passim* (London, printed 1767; published 1769); (2) Hugh Carrington, *Life of Captain Cook*, p. 324 (London, 1939).

transit of Mercury later on. He and Charles Green, the astronomer with the expedition, attained, however, extraordinary accuracy by these means.

At Tahiti, in addition to the main work, a more detailed study was made of the island and its people than had previously been attempted

in the Pacific. In this Cook himself took an important part, but the main responsibility fell upon Joseph Banks and his staff of naturalists and artists. Cook sailed from Tahiti on 13 July and was piloted by a native priest to the neighbouring islands of Huahine, Raiatea and Tahaa. Thence he turned south until the ship was in 40° s, when, as no land had been sighted, he turned west. On 7 October New Zealand was sighted—the unknown east coast; it was the first time the country had been seen by Europeans since Tasman's discovery over a century and a quarter before. Cook remained in New Zealand waters almost six months. During this time he made a complete and extremely accurate survey of its coasts; and as in Tahiti undertook with his colleagues a thorough study of the country's resources and of the way of life of its native inhabitants. For more than fifty years Cook's journals were the most important source of information on New Zealand which Europeans possessed.

By the end of March, when work in New Zealand was finished, Cook had completed the task set him by his instructions. But he still had six months' stores in hand, and, as a result of his strict attention to hygiene, the crew were still in good health. To return home seemed thus a waste of opportunity. He decided to sail for the East Indies for supplies and repairs by way of the unknown east coast of New Holland. This course was to bring the *Endeavour* into perils which, if foreseen, might have daunted even Cook. But despite dangers, and an accident which was nearly disastrous, he followed the coast from just north of Bass strait to its northern extremity, where he removed a doubt which had long troubled geographers by finding and sailing through the straits dividing Australia from New Guinea.

Writing to the Admiralty Cook summarized his own views of the voyage. 'Although the discovereys made in the Voyage are not great', he said, 'yet I flatter myself that they are such as may merit the Attention of their Lordships'. He was, in truth, astonishingly modest. In this one voyage he had added more to the knowledge of the Pacific than any of his predecessors since Magellan. But the problem of the southern continent still remained unsolved. By his course between cape Horn and Tahiti and again between Tahiti and New Zealand Cook had been able to push back much further the limits within which it could exist; but a huge area still remained quite unknown. Cook added a postscript to his journal suggesting a plan which he thought would solve the problem in one voyage more. The expedition should enter the Pacific by the Cape of

Good Hope and the south of New Holland; at Queen Charlotte sound, in New Zealand, it might refresh; and from there in early spring it should make south and then sail east towards cape Horn in a high latitude before the prevailing winds. The Admiralty authorized another voyage and inevitably Cook was given the command. His own suggestions were made the basis of his instructions; he was provided with two ships of the type he considered most suitable—vessels of small draught and strong enough to take the ground, such as were built for the North Country coal trade; and in selecting personnel he had little difficulty in finding good men eager to go with him. This time chronometers were placed on board, and although Cook was partly concerned with giving the instruments a final test, they enabled him to perform an amount of accurate surveying never before attempted by any explorer.

On 13 July 1772 the ships *Resolution* and *Adventure* sailed from Plymouth. They arrived at Cape Town in October and in November sailed for the south into weather increasingly cold, until they were forced to retreat from a field of broken ice. They crossed the Indian ocean right to New Zealand in latitudes as high as was safe and proved that no large land masses existed in habitable latitudes. A little over two months was spent in New Zealand, and then, despite the arrival of the southern winter, Cook decided to continue with his work. The ships sailed eastward in the 'forties' until they had passed the longitude of Tahiti, thus proving the absence of land in those latitudes. They then made for warmer seas. A month was spent in Tahiti and the Leeward islands, before Cook laid his course for the islands of Middelburgh ('Eua) and Amsterdam (Tongatapu) which Tasman had discovered in 1643. It took him through seas hitherto untraversed, and a group of islands previously uncharted was sighted and named Hervey's islands. Amsterdam was reached on 1 October 1773; in the few days spent there the natives showed themselves so eager to trade with the strangers and to entertain them, and there seemed such good feeling among the natives themselves, that Cook named the group the Friendly islands. From here Cook returned to New Zealand and anchored in Queen Charlotte sound, in the *Resolution*, at the beginning of November. On this passage the *Adventure* had been lost sight of in a storm; she was not to be seen again until both ships had returned to England.

Cook waited three weeks for the *Adventure*, preparing for the coming traverse of the Pacific in high latitudes. But he could wait no longer: the summer was almost upon him. And on 25 November

he sailed. By 15 December the ship was in 66° s and had to retreat from the ice. For the rest of the month and during January they continued eastward in a series of immense zigzags. On the last day of January they reached their furthest point south in 71° 10′ s, far beyond anything attained by Europeans before. From that they were driven back by ice. 'As we drew near this ice', Cook wrote, 'some penguins were heard, but none seen; and but few other birds, or any other thing that could induce us to think any land was near. And yet I think there must be some to the South behind this ice, but if there is, it can afford no better retreat for birds, or any other animals, than the ice itself with which it must be wholly covered. I, who had ambition not only to go further than anyone had been before, but as far as it was possible for man to go, was not sorry at meeting with this interruption'. He had reduced *Terra Australis Incognita* to Antarctica.

Again Cook was confronted with the problem of what to do when all that had been expected of him was completed; and again he decided against immediate return to Europe. Although there was no continent, there remained, he wrote, 'room for very large islands in places wholly unexamined, and many of those which were formerly discovered are but imperfectly explored, and their situation as imperfectly known'. The *Resolution* turned north. A large land which Juan Fernandez was said to have found in the south-eastern Pacific was proved non-existent; the position of Easter island was fixed and its huge statues described; and the Marquesas, which had not been sighted since Mendaña's visit, were rediscovered. A few weeks were then spent in Tahiti. And from Tahiti Cook set out to place finally in the framework of the Pacific Quiros's Austrialia del Espiritu Santo. As he sailed west Palmerston atoll and Niue were discovered, and on 16 July the outskirts of the New Hebrides (as Cook named the group) were in sight. In the following six weeks the whole group was charted and the places mentioned by Quiros were identified. Then Cook prepared to return to New Zealand, but more discoveries were close at hand—New Caledonia, the Isle of Pines and Norfolk island. A month was spent in New Zealand waters, and then the ship sailed for cape Horn and for home. This time, to make finally certain of the absence of any large land mass, Cook cut across his zigzag course of the preceding summer. On 30 July 1775 the *Resolution* reached Spithead. Her company had voyaged for three years and eighteen days and had sailed between sixty and seventy thousand miles.

It was seven years since Cook had first sailed for the Pacific. In those years there had been little rest. Now, he thought, retirement had been earned; he accepted a post at Greenwich Hospital. He was elected a Fellow of the Royal Society. He moved among scientists and writers in London. But he was not to enjoy this life for long. One important problem in Pacific geography still remained unsolved. In the far north the Russians had explored the coasts where Asia and America almost meet; but further south—between Alaska and California—the American coast remained almost completely unknown. Might not the long hoped for North-west Passage between the Pacific and Hudson's bay really exist? The gain to England, placed as she was on the north-western edge of Europe, of such a northern route to the Pacific and the East would have been enormous. The Admiralty decided to resolve the uncertainty. Cook was asked to suggest a leader for the expedition. The project had so interested him that he offered to go himself, and on 12 July 1776, with the two ships *Resolution* and *Discovery*, he sailed again for the Pacific.

On 12 February 1777 they cast anchor in New Zealand. From there they sailed for the Friendly islands, where they remained from April until July. They then sailed eastward to the Society islands, where another four months were spent, before sailing north in December so as to arrive on the coast of New Albion as the northern winter was ending. On 18 January 1778, sailing across unknown ocean, they sighted land. It was the first recorded time Europeans had seen the Hawaiian islands. Cook named the new group the Sandwich islands. They remained there a fortnight, and were able to enter readily into communication with their inhabitants because of the similarity of the language and culture to those of other parts of Polynesia. But their programme would not admit of further delay. On 7 March they sighted the coast of New Albion in what is now the State of Oregon, and began slowly to move northward. They discovered the great inlet of Nootka, which was named King George's sound, and here they refitted. All through the summer they sailed north, charting the coast in something like its real outline and passed through Bering strait into the seas to the north. In 70° 44′ N their progress was stopped by an unbroken barrier of ice: there might still exist a navigable passage westward, but as the summer was over they turned south to spend the winter in the Hawaiian islands.

After cruising off the coast of the islands of Maui and Hawaii for almost two months, they finally anchored at Kealakekua bay in

Hawaii in January 1779. The whole company was received with marked respect; and large gifts of pigs and vegetables and native cloth were pressed upon them. Cook himself was treated with what seemed to be adoration—as, in truth, it was. Hawaiian tradition declared that Lono, God of the Harvest, had long ago disappeared over the sea, promising to return. Cook was believed to be the god. This accounts in part for the lavishness of the hospitality. But even a god could outstay his welcome; and after the first few days doubts seem to have arisen as to Cook's deity. The people began to show the sailors by signs and by words that it was time they went. Relations remained good, however, until the departure of the ships on 4 February to survey the coast and look for another anchorage. Almost at once they ran into a storm; and a week later they were back at Kealakekua bay to repair the damage to the ships. The people were now less friendly. A series of minor quarrels developed almost at once; and on the third day Cook landed to visit his friend, the principal chief, from whom he proposed to demand hostages. The chief was willing to go on board the ships himself, but his followers were hostile. At this time word came of the death of another chief at the hands of Europeans. The situation was tense to breaking point, and a scuffle developed. The contestants were at such close range that the possession of firearms did not give the Europeans their accustomed advantage; it was a brawl, not a battle. In attempting to retreat with his men to the sea Cook was struck down. Those of his followers who could made their way to the waiting boats. They could do nothing for Cook. None witnessed his death.

When the boats returned to the ships the men in them 'cryed out with tears in their eyes that they had lost their father': even while he lived Cook had become a legend to them. And many among the Hawaiians seem also to have been grieved and shocked: to them he had been a god. Within a few days friendly relations had been re-established with the chiefs. Cook's remains were brought out to the ship and sorrowfully consigned to the waters of the bay.

On 22 February they sailed, to complete the work which had been Cook's. During the long days of the Arctic summer they sought again for a passage westward, or eastward, until they were stopped again by the ice barrier. From there they retreated. And by way of the East Indies and the Cape of Good Hope they finally returned to England to report upon their discoveries. News of Cook's death had preceded them.

Just ten and a half years had passed between Cook's first departure

for the Pacific, in August 1768, and his death in Hawaii, in February 1779. Then it was an ocean of hypothesized continents, of lands which had in some part been seen, but whose whole extent was unknown, and of islands discovered and then lost again. Now, although some parts of the ocean remained unvisited and some islands undiscovered, the main outlines of Pacific geography were firmly established. To the discovery and charting of coasts, Cook had added minute details of winds and tides and sunken reefs; he had described the lands themselves, their people, and their resources with a fulness and exactitude seldom approached by his predecessors; and, in England, he had raised popular interest in exploration and in the South Seas to the highest point which it ever attained. Within a few years colonizers, missionaries, traders and whalers were taking the first steps towards turning to practical use the knowledge which he had placed at their disposal.

Cook's last voyage had not solved completely the problem of whether or not there was a navigable passage from north-western America to the Atlantic. The final answer waited upon the voyage of George Vancouver in 1791–5. In the south Pacific another problem, not indeed of discovery but of identification, was still to absorb the attention of geographers and explorers: Mendaña's Solomon islands had been several times visited, but they had passed unrecognized. Then, in 1781, the French geographer Buâche advanced the thesis that they were the same as the islands visited by Bougainville and by Surville between New Guinea and Santa Cruz. His contention was proved correct a little over a decade later by his fellow-countryman D'Entrecasteaux. But there was no lack of work still to be done. Many coastlines were only roughly charted; the position of innumerable islands had to be verified, and even their existence proved; and winds and tides and ocean currents required careful study. If this work lacked the vast scope of the labours of the explorers, it attracted to it many men of calibre not inferior to theirs—La Pérouse, Malaspina, Krusenstern, Kotzebue, Bellingshausen, Dumont d'Urville (Plate 79), Wilkes, Owen Stanley, and many others (Fig. 82). And there were the contributions of whaling and trading captains, missionaries and white settlers in the Pacific: these men discovered numerous islands and placed rough charts of many little known parts of the Pacific in the hands of the professional cartographers. But the mere fact of their presence is an index of the change which had come over the Pacific. The age of major exploration had come to a close with the death of Cook.

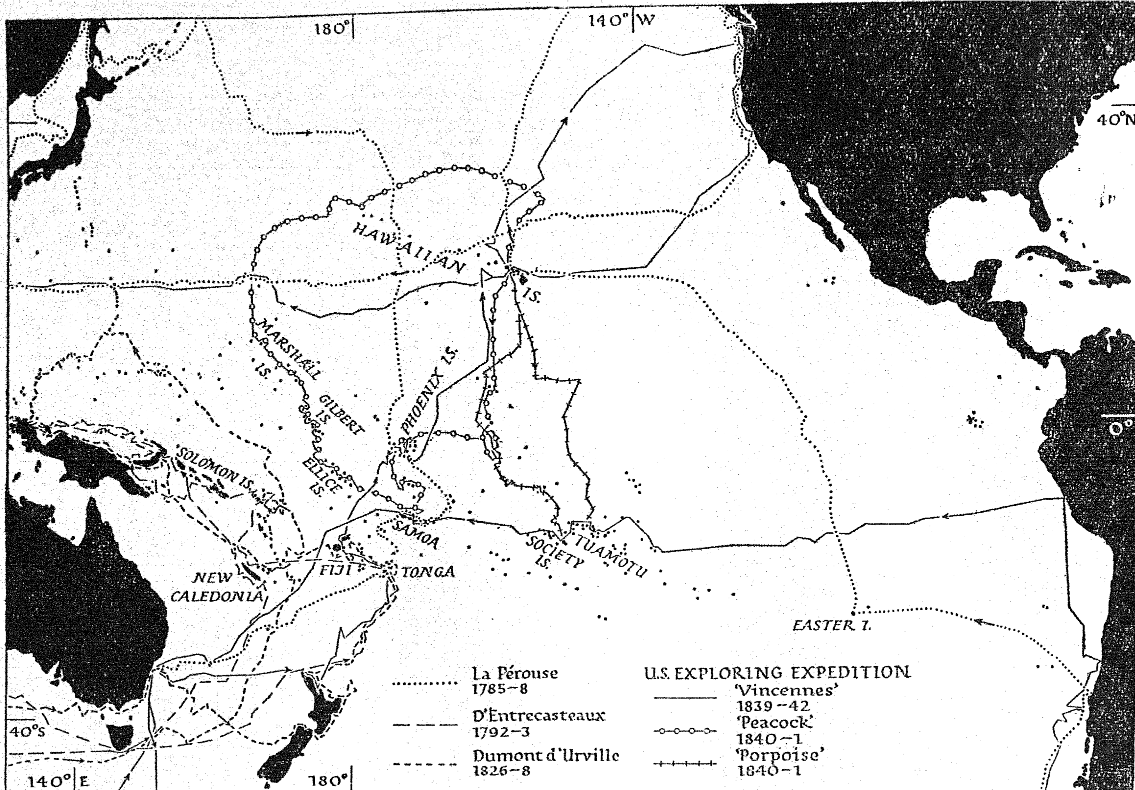


Fig. 82. Exploration of the Pacific (after Cook)

This map shows only a selection of the most important voyages in the period covered (1780–1850). For the United States Exploring Expedition, the route of the flagship *Vincennes* is shown for the whole of the time the expedition was in the Pacific; the tracks of the *Peacock* and *Porpoise* are shown only for the periods when they were separated from the remainder of the expedition and engaged on important survey work on their own. For sources see the Bibliographical Note on p. 287.

THE BEGINNING OF COMMERCIAL AND MISSIONARY PENETRATION, 1779–1843

From the time of Cook's return from his first voyage, in 1771, until the end of the eighteenth century his name was on everyone's lips. In England especially, as was to be expected, people were fascinated by what he told in his writings of the new world of islands which he had so dramatically brought to life. Interest was shown in two ways. Most men were principally concerned to draw an idealized picture of the South Seas. The interest of a smaller number, however, was more direct and practical. Traders and colonizers began to use Cook's *Voyages* as a guide to the resources of the lands of the Pacific and the masters of merchant ships to find in them much that would serve in place of a formal pilot book.

About the year 1785 British merchants began to trade for furs on the American North-west Coast. A year or two later, in 1787, Lieutenant William Bligh was sent to Tahiti in H.M.S. *Bounty* to procure breadfruit trees for transplantation to the West Indies, where it was hoped the fruit would provide a useful supplement to the diet of the slaves. Commercial penetration had thus begun. But far more important for the future was another development of the same years. The final loss of the American colonies in 1783 had left Britain with the problem of disposing of the surplus population of her prisons. The newly-discovered lands of the South Seas were at once thought of as likely to provide a suitable site for a penal colony. In 1786 New South Wales was selected for this purpose; and early in 1788 Captain Arthur Phillip, the first Governor, arrived at Sydney cove with a large party of officials and convicts. The infant settlement was to grow within a generation into a prosperous colony, and in a little over a century into the Commonwealth of Australia. Its existence brought about, from the very earliest years, the dominance of British influence in the Western Pacific.

In one way the more general interest in an idealized South Seas also led to effective action. This was in the establishment of Christian missions. The great years of Pacific exploration had also been those which had seen the growth of the English Evangelical Revival. At first the evangelicals had been almost wholly absorbed in reforming the religious state of England; but after about 1785 their attention began to turn strongly towards the subject of foreign missions. The South Seas seemed to offer an important field for

missionary activity. It appeared certain from what Cook and others had said that the natives would welcome white settlers among them; while, at the same time, it was desirable to show how far Christian opinion was from accepting the views of those who were erecting, in the guise of the noble savage, a set of non-Christian standards for the moral guidance of Europeans.

The Establishment of Christian Missions

The English missionary movement took shape during the wars with France which lasted, with one short pause, from 1793 until the final overthrow of Napoleon in 1815. One of the first organizations to begin work was the (London) Missionary Society (L.M.S.), an undenominational body founded by Congregationalists, Calvinistic Methodists, Presbyterians and Anglicans in the autumn of 1795. This society decided that the first body of missionaries it sent out should go to the islands of the South Seas. By July 1796 all was ready. And early in August, with the mission flag at her peak, 'three doves argent on a purple field, bearing olive branches in their bills', the mission ship *Duff* dropped down the Thames.

In March 1797 the *Duff* reached Tahiti, where the majority of the missionaries were to settle, and from there continued to Tongatapu and Tahuata (in the Marquesas) to land smaller parties. The difficulties which these first missionaries had to face, though often unusually severe, were essentially similar to those met with by later comers in the Pacific. And the men themselves, in their personal qualities and their social background, were remarkably representative of the general missionary type which embraced all but the most unusual men sent out to the islands by Protestant missionary societies during most of the nineteenth century. The mission party on the *Duff* had numbered thirty (excluding wives), of whom four were ordained ministers and nearly all the remainder skilled workmen. Few of them had received more than the ordinary education of members of the artisan class. They had left England without any clear conception of conditions in the South Seas. Their first impressions were profoundly depressing. They had vaguely expected a mild and gracious welcome, followed at once by a greedy demand for religious instruction. Instead, they were greeted by 'wild, disorderly' savages 'dancing and capering like frantic persons about our decks'; and years were to pass before any serious interest was taken in their teachings. Many of them gave themselves up to exaggerated despair. In general they were well treated by native

chiefs, though the common people regarded them with a mixture of curiosity and antagonism. But even behind acts of transparent kindness they tended to suspect ill-will and deceit. To them talk of the noble savage was a mere mockery. They believed that the Polynesians had been given up by God to depravity of soul, mind and body as punishment for their sins.

Thus tried, many of the missionaries were found wanting. A few —less timid but more unstable than most—surrendered completely, left their companions and went to live with native mistresses. A much larger number shrank from all contacts with the natives and left the mission field within a few years of their arrival. The stations on Tongatapu and Tahuata were wholly abandoned; and in Tahiti the majority of the missionaries left in 1798, and again ten years later, after reinforcements had been sent out, all but two temporarily gave up their work.

Outwardly, the results of their first years of work were greatly disappointing, but, in reality, much more had been achieved than was apparent at the time. In Tahiti the presence of missionaries over the whole period of ten years had greatly widened native contacts with Western culture. It had assisted the growth of trade; it had given the Tahitians an acquaintance with the domestic life of Europeans; and, most important of all, it had enabled the chief Pomare (Fig. 87) to make a successful bid for supreme power over the whole island. Pomare himself well knew that his victory depended upon his ability to obtain assistance from Europeans, especially by the supply of firearms. In 1812 he publicly embraced Christianity. When he finally overcame his enemies three years later, the mass conversion of his subjects soon followed.

The conversion of Tahiti led within a few years to that of the whole Society group. The swiftness of the change astonished even the missionaries. Chiefs whose manner of life had recently differed scarcely at all from that of their ancestors were now regular church-goers, learning to read and write in the schools, and carrying on trade in their own vessels with the colony of New South Wales. But the events in Tahiti had repercussions even further afield. Communication by canoe between islands widely separated had always existed in Polynesia: at times long voyages were deliberately undertaken, while at others canoes were driven by the wind to places far from their intended destination. Now, with the coming of European ships, Polynesians were beginning to travel even further from their homes. Before many years had passed the victory of Pomare and

the missionaries was being talked about in islands thousands of miles away. Often the story was known only at third or fourth hand; but one element in it survived all distortion—it always emphasized the power of the white man and of the God he worshipped.

The time had come for the Society islands mission to extend its work into neighbouring groups. The missionaries themselves had gained a new confidence from their recent successes. Those of the older men who still remained had lost their earlier timorousness; and in 1817 and following years a number of fresh workers arrived from England. Among the new men were several of outstanding ability. It was one of them, John Williams, who took the lead in the new movement of expansion. Williams had formerly been an ironmonger's apprentice in London. He arrived in Tahiti in 1817 and settled in Raiatea in the following year. He quickly gained great influence with chiefs and people. But his was a restless spirit. 'For my part', he wrote, 'I cannot content myself within the narrow limits of a single reef'. Impetuous and barely equal to the physical strains of a missionary life, he was a born leader and preacher, and he showed an unshakable persistence in the cause. In 1827, realizing the disadvantages of relying for transport upon the goodwill of others, he built a vessel of about 60 tons for himself at Rarotonga, using only the most primitive tools and lacking much that is normally considered necessary in the way of materials. He named her *The Messenger of Peace*. In her he made some of the most successful voyages ever undertaken by missionaries, bringing the Gospel to numerous islands where it had previously been unknown.

The first new mission stations had been founded in the islands of the neighbouring Austral and Cook groups. In 1819 King Pomare of Tahiti had visited Raivavae, in the Australs, and left a native teacher there. Early in 1821 a vessel belonging to him called there, and it was found that a large chapel had been built and that nearly all the people were professing Christians. This news immensely encouraged the Tahitian church and led at once to a determined effort to evangelize the remainder of the group. At the same time the Cook islands were brought within the fold. In both groups the greater part of the work was done by native teachers from the Society islands.

The Society islands mission was also trying to obtain a footing in Tonga and the Marquesas at this time. Native teachers were landed on Tongatapu in 1823. And in 1825 and following years a number of visits were made to the Marquesas, where native teachers were

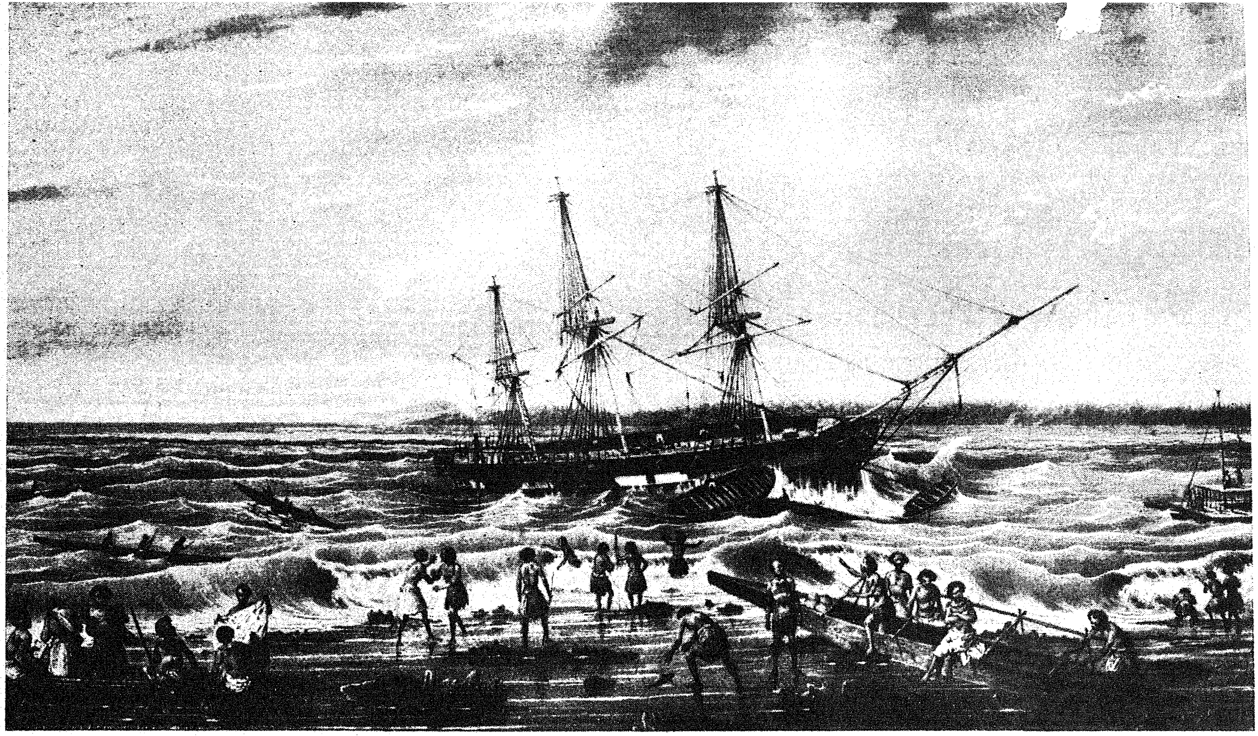


Plate 79. The corvette *L'Astrolabe* aground on the reef at Tongatapu

In his search for news of the fate of La Pérouse's expedition (p. 275), Dumont d'Urville visited Tongatapu in April 1827. His ship went ashore on the reef but was later refloated. From Jules Dumont d'Urville, *Voyage de la corvette L'Astrolabe. . . .*, atlas, plate 67 (Paris, 1833).

Plate 80. Fighting between Dumont d'Urville's men and natives of Tongatapu

When Dumont d'Urville prepared to leave Tongatapu in May 1827, Tongan chiefs seized several of his sailors, whom they wished to have living with them. Fighting took place for two or three days before the men were returned to the ship. From Jules Dumont d'Urville, *Voyage de la corvette L'Astrolabe. . . .*, atlas, plate 92 (Paris, 1833).

established—though with much difficulty—and a European mission finally re-established in 1834—35 years after the first attempt in Tahuata had been abandoned. A much more important advance, however, was begun in 1830. In that year John Williams and Charles Barff visited Samoa. They were astonished by its fertility and its populousness. It seemed to them to be the most important group in the South Seas, except for Hawaii. They were well received. Rarotongan teachers were left in the islands. A year later Williams visited Samoa again and found the people clamouring for teachers wherever he went. The missionaries in the Society islands and the home authorities shared his enthusiasm for the new field of work. The first European missionaries settled in the islands in 1835. By 1842 their number had been increased to fifteen; and by that time the missionaries believed that the majority of the Samoans were Christians.

But even before the first visit to Samoa, Williams had formed still another plan. The whole of Melanesia remained untouched. Fiji and the New Hebrides, in particular, were in need of Christian teachers, for their peoples had already suffered from the brutality of unprincipled traders. Until his return from a visit to England in 1839, however, his energies were fully absorbed elsewhere. In November of that year he was at last free to sail for the New Hebrides. The island of Tana was visited, and the missionary party was received so well that Williams landed native teachers there. They sailed thence for Eromanga, where again the reception seemed friendly. But then, quite without warning, the missionary party was attacked. Williams and a colleague, Harris, were killed almost instantly. They had paid for the crimes of sandalwood traders who had recently visited the island.

Williams' influence long survived him. In the South Seas the legend of his life and death formed a bond holding together the peoples to whom he had brought Christianity; while in Britain the example of 'the martyr of Eromanga' has been used continually to rouse into new life the dwindling flame of missionary enthusiasm.

Meanwhile, other missionary bodies had begun work in the Pacific. In 1814 the Church Missionary Society founded a station in New Zealand, from which within 25 years it spread out over most of the North Island. In 1820 the first missionaries sent out by the American Board of Commissioners for Foreign Missions arrived in the Hawaiian islands. (The Hawaiians had already been in close contact with European influences for over thirty years. As a result there was

already widespread interest in Christianity; and the teachers found themselves, from the beginning, with a strong body of supporters). In the same year, 1820, the English Wesleyan Missionary Society appointed its first missionaries to New Zealand and Tonga: they began work in both fields two years later. And in 1835 the same society extended its work to Fiji. Thus by the middle 'thirties all the major groups in Polynesia had been brought within the range of the Protestant missionary movement. In Fiji the Wesleyans had entered Melanesia; but their work there did not make much progress until after 1840; and to that later period the evangelization of other parts of Melanesia belongs.

The members of all the Protestant missionary bodies maintained a friendly co-operation which was never seriously interrupted. The L.M.S. lent the services of one of its missionaries from the Society islands to the Americans during their first years in Hawaii; and its native teachers assisted the Wesleyans in both Tonga and Fiji. In New Zealand the Church Missionary Society and Wesleyan missionaries gave one another much assistance. But the arrival of Roman Catholics introduced a less happy period, marked by considerable friction. In 1833 the Pope had created two vicariates in Oceania and placed them under the care of two French missionary orders—the Congregation of Picpus and the Society of Mary. Between 1834 and 1842 Roman Catholic missionaries attempted to enter most of the fields in which the Protestants were already working—the Hawaiian islands, the Marquesas, Tahiti, Tonga and New Zealand. Co-operation was never considered by either side. By 1841 the Catholics had ousted the L.M.S. from the Marquesas, though without making any notable impression upon the natives themselves. Elsewhere, except in the vicinity of the Picpus headquarters at Mangareva (Plate 81), they were at that time generally unsuccessful: Protestantism was inextricably connected with the whole way of life of the Christianized populations.

The Growth of Trade and Settlement

The growth of the fur trade on the American North-west Coast in the years after 1785 first brought merchant ships among the Pacific islands. A few years later whaling developed off the Chilean coast. But the fur traders called only at the Hawaiian islands with any regularity, and the whalers at this time remained far to the eastward of Polynesia. Trade in all the main island groups of the Pacific, with the exception of Hawaii, began as a consequence of the

settlement of New South Wales; and until the middle of the nineteenth century nearly all its major developments occurred as aspects of Australian expansion.

The whaling grounds of the south-western Pacific were tried by vessels from Sydney within a few years of the foundation of the colony; and after the outbreak of war between Britain and Spain in 1796 British whalers deserted the Chilean coast for that of Australia. By 1801 they had spread eastwards towards New Zealand, where they were soon fishing in considerable numbers, and north-eastwards towards Tongatapu and Tahiti. Wherever possible they established contact with the natives of islands near the whaling grounds—trading beads, iron tools and muskets for fruit and vegetables, pork, and other native produce. But misunderstandings were frequent. Hostilities often resulted. And when Europeans were killed in the course of these disputes, a legend of native ferocity arose which in some places kept whale ships away for several years. The whalers' visits were too short to bring about by themselves the sort of mutual understanding which is necessary for the foundation of permanent trade. This was usually attained only with the beginning of some form of commerce which compelled Europeans to remain on shore for considerable periods.

The earliest of such trades was that to northern New Zealand for kauri timber, which began in 1794. The first ventures, however, were financially unsuccessful, and they were not followed up systematically until thirty years later. More important was the action of Governor King of New South Wales in sending vessels to Tahiti in 1801 and following years for pork. King was concerned not only with obtaining salt provisions for the colony economically but with demonstrating to the Tahitians the advantages of regular commerce. Both these objectives were largely attained. Sydney merchants followed his example, and year by year they sent vessels to purchase pigs from the chiefs of Tahiti and the other islands of the Society group. The growth of the trade was limited, however, by the extent of supplies. In the commerce of the infant colony the pork trade was not altogether without intrinsic importance; but its principal usefulness was in arousing the interest of colonial merchants in the future possibilities of trade with the South Sea islands.

An opportunity to experiment on a larger scale was provided just as the excitement of the first voyages to Tahiti was subsiding. In 1804 it became known in Sydney that sandalwood (p. 169) had been discovered in Fiji. The previously known supplies of this wood,

principally on the Malabar Coast and in Timor, were very limited. At this time it was selling for about £100 a ton in China, where it was highly valued for its fragrance and was burnt in temples, used in making fans and other small objects, and mixed in cosmetics. Those who knew the exact position of 'Sandal Wood Bay' (Mbua bay, in Vanua Levu) saw the possibility of making large fortunes out of their knowledge. They hurriedly despatched ships. But the secret did not survive the first voyages. In 1807 a general rush began. Many Sydney merchants sent out vessels; other ships arrived from America; and a few came from India. New supplies were found—in other parts of Vanua Levu and in Viti Levu. But within a few years a decline set in. By 1810 the height of the rush was over; and by 1815 the trade was dead. Supplies were undoubtedly becoming scarce; but the decisive factor in killing the trade was the hostility of the Fijians. The last two ships to visit the islands both lost some of their men at the hands of the natives. It was the reward of almost consistent brutality on the part of the Europeans.

But profits had been immense while the trade had lasted. The expenses of a voyage from Sydney to Fiji and back by a vessel of the type that was used—brigs of from 100 to 200 tons—cannot have exceeded £2,000 (even if the most lavish allowance is made for depreciation), but the proceeds were at times at least £9,000. Those who knew anything of the conditions in the trade were thus continually hoping to obtain news of the discovery of new sources of supply. A small amount of sandalwood was obtained in the Austral islands; and there were rumours, which proved baseless, of its existence elsewhere. But early in 1815 Sydney was given effective evidence of a new discovery: William Campbell, one of the most experienced of Pacific traders, had arrived with over 50 tons of sandalwood obtained at Nukuhiva, in the Marquesas. Other ships were quickly sent off to that island. A number of good cargoes were obtained, but by the end of the year available supplies had been nearly worked out. It was almost 25 years before Sydney merchants again engaged in the trade on an extensive scale.

Meanwhile, however, an even more important source of supply than Fiji had been tapped. Sandalwood had been discovered in the Hawaiian islands by American callers soon after 1790, but its value had apparently not been realized. Trade really began in 1811, when three enterprising Americans collected a cargo and carried it to China. Their success brought many more American ships to the islands. By making the sale of sandalwood a royal monopoly

King Kamehameha I soon revolutionized the finances of his kingdom, and at the same time prevented many of the abuses which usually crept into the trade between inexperienced natives and shrewd, and often unscrupulous, Europeans. After his death in 1819, however, the trade was thrown open by his successor. A wild orgy of selling and spending began. Chiefs were persuaded by the traders to buy all kinds of luxuries, giving in return promissory notes payable in sandalwood. To pay their debts they were compelled to demand long spells of work in the forests from their people. Food crops were neglected and health suffered. Traders embarked on a policy of agitation and appeals to warships, in order to get native engagements fulfilled—ever afterwards the native authorities were to be worried by this form of European activity. And within a few years ruthless cutting destroyed nearly all the sandalwood in the islands.

By about 1829 the boom was over. European traders and native chiefs who had developed a taste for commerce found themselves with their principal occupation gone. A few looked towards the islands of the south Pacific. Shop-keeping in Tahiti and a search for sandalwood in the Australs were both tried but without success. More ambitious projects followed. Late in 1829 it became known in Honolulu that sandalwood was plentiful on the island of Eromanga in the New Hebrides. A number of expeditions set out. One, under the command of the chief Boki, had political as well as commercial aims. Boki planned to make himself governor of Eromanga, but his ship was lost on the voyage southward. Owing to the outbreak of hostilities between the Eromangans and the timber-seekers trade did not develop. Towards the end of 1830 another Hawaiian adventure was begun. A group of merchants in Honolulu despatched two ships under the command of the half-caste Hawaiian George Marina to found a settlement on Uvea (Wallis island), as a centre for the development of trade with Fiji. By lavish gifts and a flamboyant manner Marina obtained great power on the island; but he soon became tyrannical. About a year after his arrival the Uveans rose against him. He was killed, and the settlement was abandoned. Hawaiian intervention in the south Pacific was not resumed for many years.

Though sandalwood absorbed most of the attention of Pacific islands traders until about 1825, it did not exhaust it. The minor trade in pork at Tahiti continued spasmodically, and occasional voyages were still made to New Zealand for timber. There had been

a flickering of interest in *bêche-de-mer* (the edible sea-slug, much prized in China). And pearling had begun in the Tuamotu archipelago. Since 1803, at least, the existence of pearl oysters in that group had been known. But the exact location of any of the beds was not discovered until 1809. During the years from 1809 until 1813 many profitable voyages were made from Sydney. In this industry the chance of conflict between natives and Europeans were even greater than in the sandalwood trade of Fiji, for the party of native divers lived side by side with the European crew on board ship. In one instance, the voyage of the *Daphne* in 1812-13, extreme brutality by the master and mates led to a mutiny by the native divers, in which the master and two others were killed and the remaining Europeans marooned on a nearby island. The details of this story were particularly unpleasant and it was, at least in part, responsible for the temporary abandonment of the trade.

By about 1816 practically all Sydney trade with the south Pacific

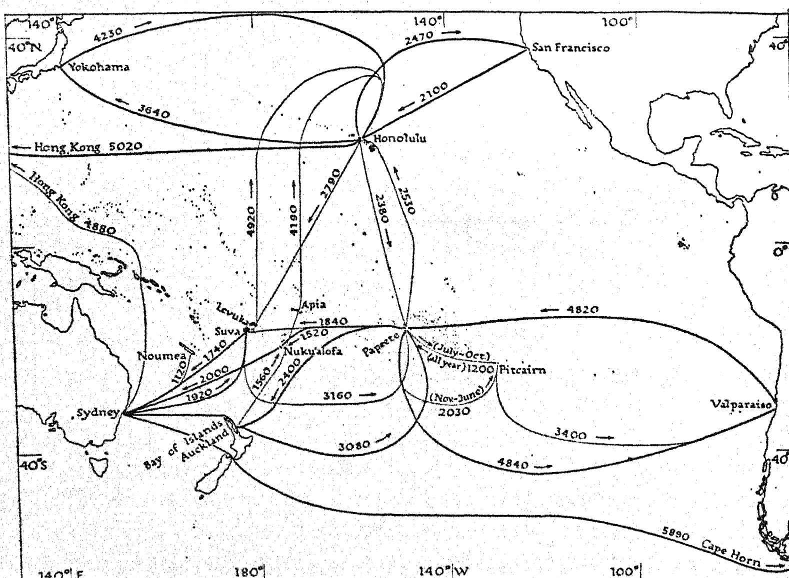


Fig. 83. Sailing-ship routes in the Pacific

This map shows how the prevailing winds affected the opening up of the Pacific. A voyage from Sydney to Papeete and then back to Sydney, for example, usually involved intermediate calls in northern New Zealand and in the Tonga group. Based on: (1) Admiralty chart no. 1078; (2) records of actual voyages.

was thus at a standstill. For the time being merchants and others preferred to invest in less risky ventures within the colony. When they again became interested about eight years later their attention was attracted principally by New Zealand. It had always been potentially the most important group in the Pacific; but it had not offered prospects so immediately dazzling as Fiji, and its native inhabitants were not as tractable as those of the Society islands. By 1825, however, the situation had changed. In particular, the fact that a mission station had existed at the Bay of Islands for eleven years had greatly reduced previous fears of the Maori. Traders and settlers from the Australian colonies now began to build up an extensive trade, at first in flax and timber and later in a variety of other products. By 1839, when Britain decided to annex the country, Australian overseas expansion in New Zealand was second in importance only to the overland expansion from Sydney which had created the new settlement of Melbourne.

Expansion within Australia, and to New Zealand, was absorbing all the money available in Sydney for investment. Trade with tropical Polynesia did not revive. Every year a few ships sailed from Sydney for the islands, often under contract to deliver stores to the missions. Because of the winds their route usually took them among many islands other than those to which they were bound (Fig. 83). They brought back coconut oil, arrowroot, sugar, molasses, lime juice and sennit from the Society islands, pearl shell from the Tuamotu archipelago, *bêche-de-mer* and 'tortoise' (turtle) shell from Fiji, and pork and tropical fruit from many of the islands. But the total value of the trade was small—only a few thousand pounds each year. The bulk of the commerce of the islands had passed into other hands.

In the late 1820's American sailors returned to Fiji to develop a trade in *bêche-de-mer* and turtle shell with Manila and Canton. Conditions in the group were almost unchanged since sandalwood days. It was still largely unsurveyed (Fig. 84) and still outside the sphere of missionary activities. Risks were thus heavy; but the profits of successful enterprise—the cargo of a 150 ton brig would sell for from £3,000 to £7,000—proved adequate compensation. Some of those who tried the trade returned many times.

The collection and curing of *bêche-de-mer* demanded the co-operation of a large party of Fijians over a period of some months. First, there were buildings to be erected on the beach for cooking and storing the fish and to hold the trade goods; and then a great

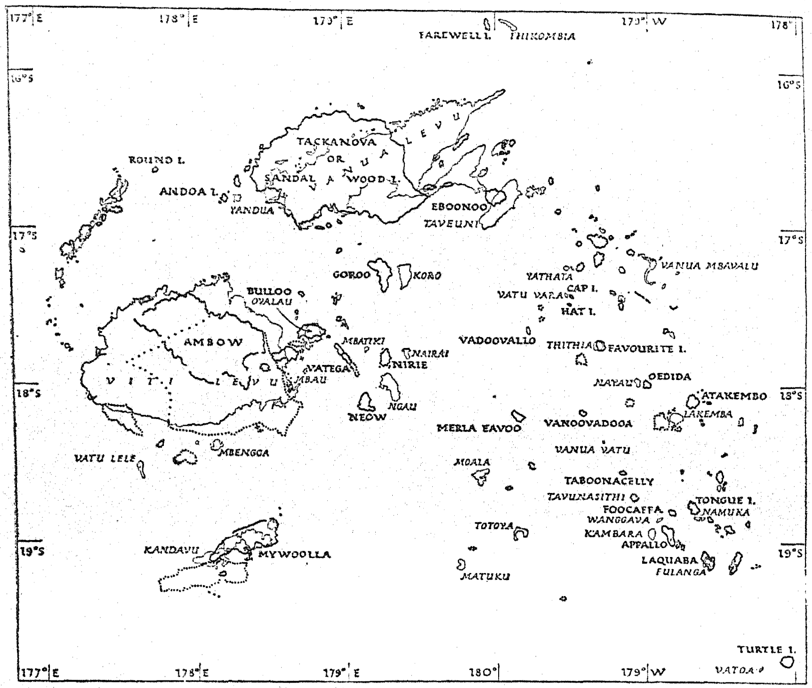


Fig. 84. Fiji, as shown on Arrowsmith's chart of 1814

The 'Chart of the Feejee Islands' published by Aaron Arrowsmith in 1814 was the first to show the group in anything like its actual form; it was based mainly on information collected by sandalwood traders. The outlines of the islands as given by Arrowsmith are shown here by a heavy line and his names in heavy roman lettering. The dotted lines represent additions and amendments made by H.M.S. *Victor* in 1836. The actual outline of the group, as built up from more recent surveys, is shown by a thin line; the current official names of the islands are given in italic lettering. Many of Arrowsmith's names are crude attempts to render the names which are still accepted: e.g., Vatega (Mbatiki) or Bulloo (Ovalau). For the largest islands names are given by Arrowsmith which really apply only to much more restricted areas: Ambow (given for Viti Levu) is an attempt to represent Mbau (the name of an off-lying islet); Tackanova (for Vanua Levu) represents Thakaundrove (a district); and Eboonoo (for Taveuni) is probably for Vuna (also a district). Based on E. im Thurn and L. C. Wharton (editors), *The Journal of William Lockerby, Sandalwood Trader in the Fijian Islands during the Years* 1808–1809 . . . (*Hakluyt Society Publications*, 2nd series, no. 52, London, 1925).

army of workers was employed in collecting the *bêche-de-mer* from the reef, in gathering food and firewood, and in helping with the curing (Plate 84). If a serious dispute arose the trader was likely to have

his buildings burnt down and his stocks destroyed. The possession of a competent interpreter was therefore of the greatest importance. This demand created a supply. A small number of responsible men left their ships, and about 1835 they formed a settlement at Levuka, on the island of Ovalau, where they were regularly engaged by incoming ships for the period of their stay in the group. This was the nucleus from which the later colonization of Fiji grew.

The Americans were, in general, the most enterprising of the trader-adventurers of the Pacific; but the best representative of the class was the Irishman Peter Dillon. Dillon was far more than a trader: the achievement of which he was himself most proud was his discovery nearly forty years after the event, of the fate of the French explorer La Pérouse, some of the wreckage of whose ships he found on the shores of Vanikoro, in the Santa Cruz islands. But, despite his success both as a writer and explorer, Dillon's best work was connected with commerce. He had come to the Pacific as a young man in 1808. He took part in the earlier sandalwood trade and in the pork trade of Tahiti. He lived among the people of many of the islands, and he knew most of the missionaries—served them and quarrelled with them. Somewhere about 1820 he acquired a ship of his own; and between that time and his retirement in 1838 he pioneered many branches of trade. He opened up trade between Valparaiso and both Tahiti and New Zealand; he was the first to return to the deserted islands of Fiji after the end of the sandalwood trade; and he discovered the sandalwood of Eromanga. He not only prepared the way for later traders, however, but demonstrated to large numbers of natives the workings of European commercial enterprise. He employed many of them as sailors, and carried their chiefs as passengers to Sydney and Valparaiso and Calcutta. The presents he brought back from his voyages for his native friends were still cherished long after he had gone. His name became almost a legend in his own day, and it was still remembered in the Pacific both by his friends and his enemies (of whom he had a number, particularly among missionaries) many years after he had retired to Europe.

Most important of all, however, in giving the Polynesians knowledge of commerce and shipping was the establishment in both the Hawaiian islands and the Society islands of a local marine. The first experiments in ship-owning of Kamehameha I of Hawaii and Pomare II of Tahiti were soon followed by other chiefs. Their vessels, ranging from brigs of between 100 and 200 tons to small

schooners and cutters, were employed partly in the personal service of their owners, partly to assist the missionaries and partly in commerce. They made voyages from Hawaii to China, the American coast and the Russian settlements in the far north of the Pacific and from the Society islands to Sydney. On these long voyages, native-owned vessels were normally under the command of a European master; but they often traded among the islands manned entirely by natives. Native trading ventures were very often financially unsuccessful. Nothing, however, could diminish Polynesian interest in ships and the sea. To them the ship was among the most remarkable of the material changes which Europeans had introduced into the life of the Pacific. They threw themselves into the task of building and handling these vessels with the same enthusiasm with which their fathers had perfected their knowledge of canoes.

Commercial development in the Hawaiian islands, of which native ship-owning was perhaps the most significant part, had, of course, been brought about by the sandalwood trade. In the Society islands it arose from several separate causes. The first impetus was given by the conversion of the islands to Christianity. This led to the earliest attempts by native chiefs to embark on large-scale trade. Then a little later, in the middle 'twenties, several men related to missionary families in the islands set up as traders and ship-owners. These men were all notably fair in their dealings; and, because of a wide sympathy with the Polynesians, they were able to play an important part in opening up new branches of trade and establishing contacts in islands previously outside the range of commerce. The third factor was the entry of Chilean traders into eastern Polynesia.

In Chile, as in the neighbouring republic of Argentina, trade grew rapidly after the attainment of independence. Europeans of many nationalities settled in the seaport towns, established merchant houses, and built up a Chilean merchant fleet. Voyages by Dillon and others aroused interest in the islands. In 1828 a syndicate was formed in Valparaiso to develop trade with Polynesia; and one of its members took up residence in Tahiti to exercise a general supervision on the spot. The group was interested in all branches of trade, but the development of the pearl fishery was its primary concern.

Since the first phase of pearling in the Tuamotu archipelago had ended fifteen years before there had been several attempts to revive the industrv. One of them, by a London company which proposed

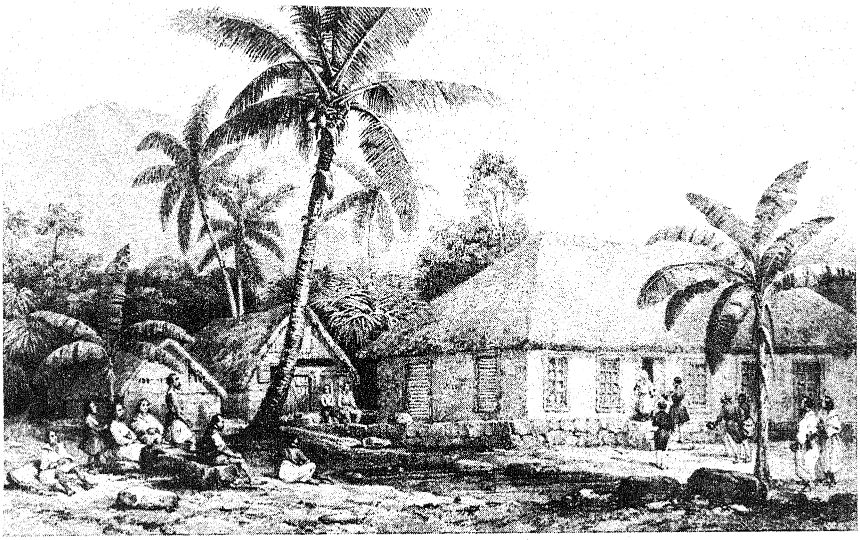


Plate 81. The bishop's house, on Aukena island, Mangareva

This lithograph shows the Roman Catholic bishop welcoming Captain Dumont d'Urville and his party in August 1838. The house was built of coral blocks. From Jules Dumont d'Urville, *Voyage au Pôle Sud et dans L'Océanie. . . .*, atlas pittoresque, tome I, plate 39 (Paris, 1846).

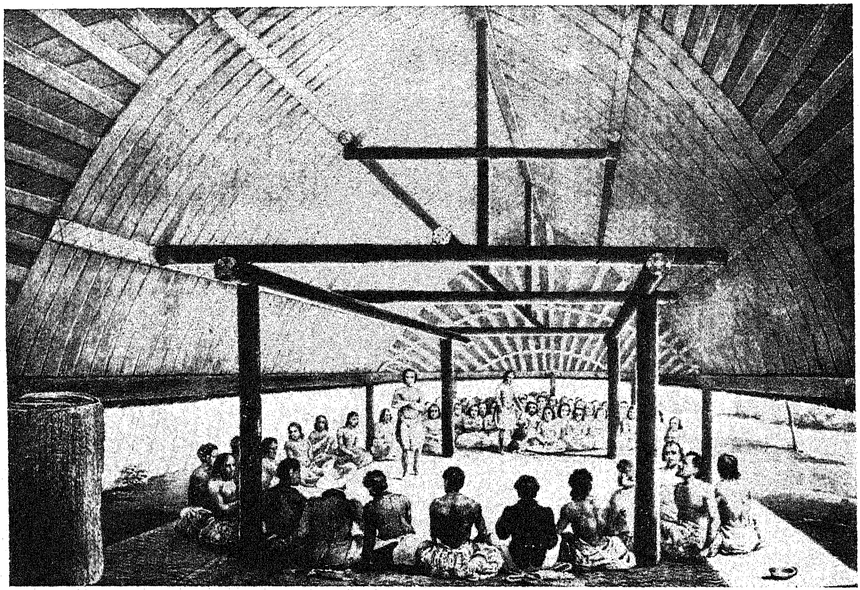


Plate 82. Kava ceremony, at Mu'a, Tongatapu

On this occasion, in May 1827, the chiefs were welcoming a party from Dumont d'Urville's expedition. From Jules Dumont d'Urville, *Voyage de la corvette*

Plate 83. Rewa village, Viti Levu, Fiji, in 1840
From Charles Wilkes, *Narrative of the United States Exploring Expedition. . . .*, vol. III, plate facing p. 109 (London, 1845).

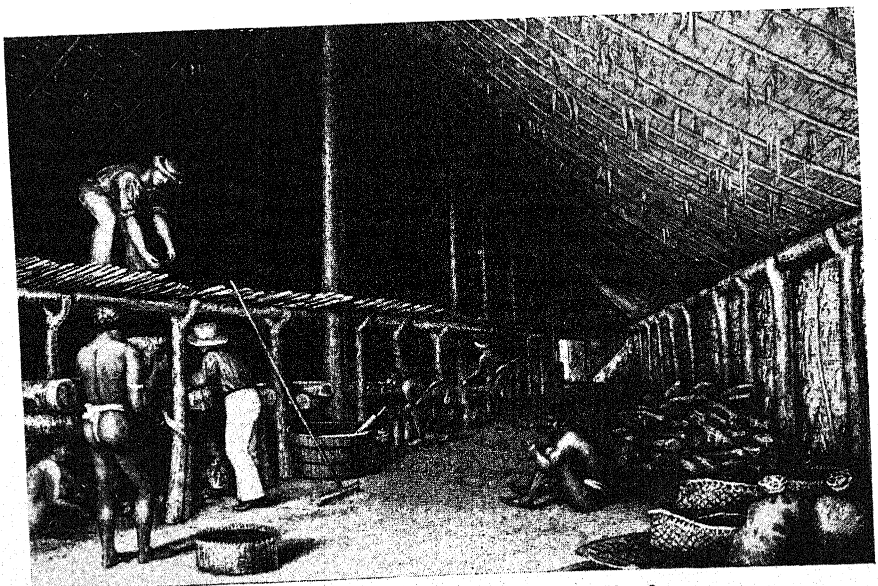


Plate 84. *Bêche-de-mer* house in Fiji, 1840
Both the upper and lower platforms were covered with reeds, and the *bêche-de-mer* was then placed upon them for curing. Beneath the platforms a trench was dug, in which a slow fire was kept burning. From Charles Wilkes, *Narrative of the United States Exploring Expedition*, vol. III, plate facing p. 220 (London, 1845).

the revolutionary expedient of dispensing with native divers by the introduction of a diving bell, had been on an ambitious scale. But all alike had failed. The Chilean venture, however, was to prove a success. The known beds were of limited extent; and probably only three or four ships could work them each year without producing early exhaustion. Also the old dangers remained: a number of vessels were seized by their divers or by the people of the islands at which they happened to be anchored. But, despite these limitations and difficulties, pearling returned good profits to the comparatively small number of merchants engaged in the trade.

Besides pearling the Chileans had other lesser interests. They obtained cargoes in the Society islands in return for rum and muskets and cheap cotton cloth; and occasionally a vessel travelled as far west as Fiji for *bêche-de-mer* or to New Zealand for timber. And in addition, they stimulated the whole mercantile community of Tahiti into more vigorous activity. They employed many of the locally-owned vessels themselves, and demonstrated to their owners the profitableness of new forms of enterprise.

But widely as the trade of the Pacific islands had spread, stretching out from the Hawaiian islands to New Zealand, from the Tuamotu archipelago to the New Hebrides, and drawing to it ships from the Society islands and Hawaii, from India and Chile, from Massachusetts and from New South Wales, the vessels engaged in it made up only a small proportion of the shipping of the Pacific. The traders were specially important because they brought natives and Europeans so firmly together; but they were far outnumbered by the whalers, whose activities were increasing steadily during the 1820's and '30's. In sum, the trading they did for provisions in the islands was of considerable value. Their four greatest ports of call were Honolulu and Lahaina, in the north, the Bay of Islands in the south, and Papeete, in the tropical south Pacific. In the year 1838, for example, 76 whalers called at Honolulu, 72 at Lahaina, 102 at the Bay of Islands and probably about 60 at Papeete. Smaller, yet considerable, numbers called at Tongatapu and Vava'u in Tonga, at Rarotonga in the Cook islands, at Kandavu and Ovalau in Fiji, at Upolu and Tutuila in Samoa, at Huahine and Raiatea in the Leeward group of the Society islands, and at Pitcairn. And apart from these regular ports of call, the whaler touched ashore in all corners of the Pacific In hundreds of islands the whaleship was the only contact the people had with the Western world (Fig. 85).

One of the most far-reaching consequences of these frequent

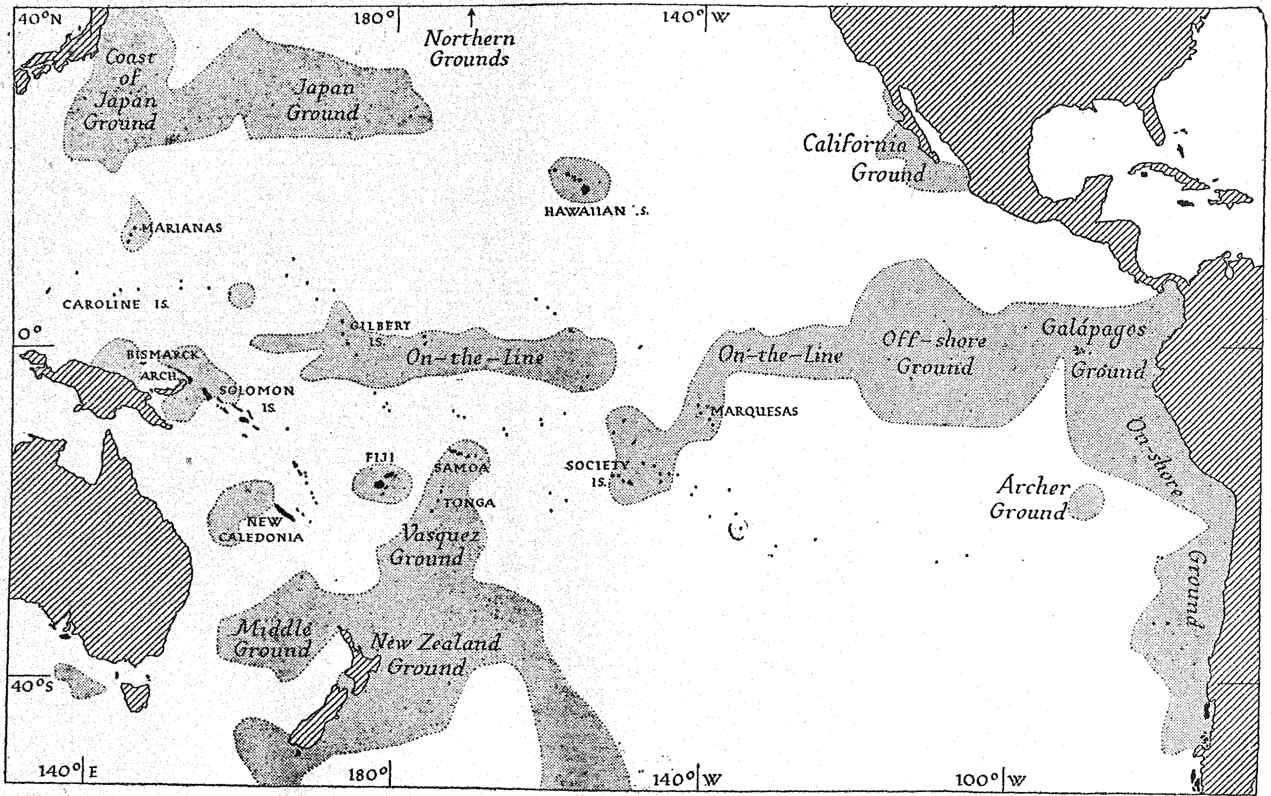


Fig. 85. Whaling grounds of the Pacific in the nineteenth century

calls by whaling and trading vessels was the increasing settlement of Europeans among the islands. From the earliest period of European commercial activity in the Pacific there had been beachcombers living in many of the islands. But the majority of these men conformed in large measure to native ways of life and played only a minor part in the advance of Western commerce. The formation of a solid core of commercial settlement was the work of men of greater substance. Between 1830 and 1840 reputable traders established themselves in a number of islands in the Pacific. But only in the Hawaiian islands, at Tahiti, and in New Zealand had settlement taken place on any considerable scale. The settlers of Hawaii and Tahiti maintained themselves in broadly similar ways. From Hawaii some carried on trade with the American coast. In Tahiti the more prominent settlers were interested in the commercial development of most of southern Polynesia. In both groups some attention was paid to tropical agriculture—particularly to the cultivation and manufacture of sugar. The biggest source of income, however, in the Hawaiian islands, and probably the biggest also in Tahiti, was the trade with the whalers. The more substantial merchants devoted themselves to supplying provisions to the ships, while numbers of less reputable men ran grog-shops, which were a mixture of public house, brothel and smuggler's den.

Prices were generally higher at Honolulu and Papeete than at the remoter islands; but supplies were more certain at these established ports. And there was another factor of great importance to men who had been long at sea: Tahiti and Hawaii were the most 'civilized' places in the South Seas. Money was in general use. Many of the settlers lived in good houses and possessed solidly-built stores. And the natives often spoke at least a few words of English. The establishment of permanent commercial settlement, in fact, set in motion changes which struck deep into Polynesian society.

Fig. 85. Whaling grounds of the Pacific in the nineteenth century

The shaded areas show where whales were most frequently caught. They give, in generalized form, the results of the work of Dr. C. H. Townsend who, with assistants, searched the logs of over 1,600 voyages by nearly 750 American whaleships and plotted on large maps the points at which just under 54,000 whales were taken. (Not all—but a large part—of this data applies to the Pacific.) The names given to the various grounds are those which were in general use among whalers at the time. Based on C. H. Townsend, 'The Distribution of Certain Whales as shown by Logbook Records of American Whaleships', *Zoologica: Scientific Contributions of the New York Zoological Society*, vol. XIX, pp. 1–50, plates 1–4 (New York, 1935).

Natives became more and more concerned, as traders themselves and as wage-earners, in all the processes of Western economic life. Where the missionary had failed to teach by precept, the trader often successfully taught by example. Commerce and settlement, like missionary work, progressively broke down old native ways of thought and action and played a vital part in the Europeanization of Polynesian society.

The Origins of Political Intervention

The influence of the trader and the missionary, it has been shown, was not confined to the spheres of economics and religion. Their coming brought about revolutionary changes in all aspects of native

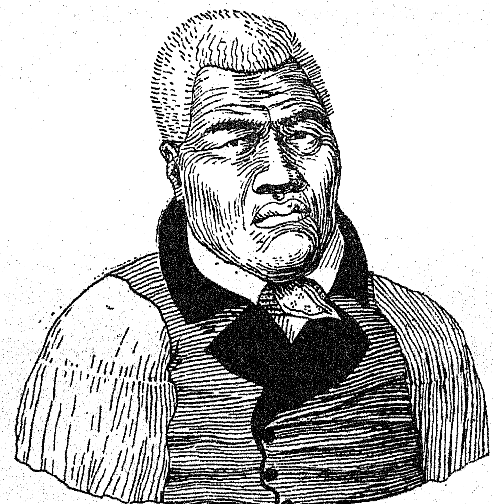


Fig. 86. Kamehameha I of Hawaii

After a portrait by Louis Chloris, reproduced in Ralph S. Kuykendall, *The Hawaiian Kingdom*, 1778–1854, *frontispiece* (Honolulu, 1938).

society. On the political side this took the form in all the larger island groups of the replacement of many tribal, or sometimes more nearly feudal, societies by a smaller number of unified states organized on European lines, and exercising authority over whole islands or over a whole group of islands. The most notable of the new states during the first half of the nineteenth century were the kingdoms of Hawaii and Tahiti.

The basic causes of this change in political organization were everywhere the same. Certain chiefs, such as Kamehameha in Hawaii and the heads of the Pomare family in Tahiti, established friendly relations with Europeans earlier than any of their rivals. Often the fortunate chief owed his initial advantage to chance—to the existence within the territories over which he ruled of a good harbour of or some product valued by traders, such as sandalwood. But soon he would come to realise the importance of the new contact and exert himself to maintain it. By this means, European goods would be obtained. These could be used to secure and to maintain

Fig. 87. Pomare II of Tahiti

After a portrait in William Ellis, *Polynesian Researches*, vol. 1, *frontispiece* (London, 1829).

the loyalty of native allies; and the possession of firearms, in particular, gave immense advantage in war. Thus, greatly strengthened and impressed by the stories told him of the achievements of European rulers and soldiers, the ambitious chief was led into great campaigns of conquest. In these his European friends always showed themselves willing to help him. Trading vessels would transport his armies; sailors and others would sometimes take up arms on his behalf; and even missionaries would often become recruiting agents for him. But usually most important of all was the work of those Europeans who acted as his permanent advisers.

Such men, who ranged from the missionary Nott in Tahiti, to the sailors Young and Davis in Hawaii, and Charles Savage in Fiji, not only enabled their chief to develop close relations with traders and other visitors but showed him how to turn to fullest advantage in warfare the new weapons which he had obtained.

Victory in war, however, was but the first stage towards the creation of a stable native government. Occasionally a very able ruler, like Kamehameha I of Hawaii (Fig. 86), might be able to hold his new dominions together by more or less traditional means. But this was exceptional. Usually new governmental machinery had at once to be devised. Such was the case, for example, in Tahiti. There Pomare II (Fig. 87) had finally defeated his enemies in 1815. Four years later, in 1819, a code of written laws was adopted; and in 1824 a parliament was set up. Formal courts of law, with trial by judge and jury, were constituted; taxation, provided for by statute, replaced the old payments of tribute; and a whole new hierarchy of 'judges', 'ministers of state', and 'governors' was created for the administration of the kingdom. These changes still further increased the importance of European advisers. They had to suggest the outlines of the new system, to explain its manner of working, and to supervise its administration. At the same time, especially after the death of the despotic Pomare II in 1821, the more able chiefs gave increasingly loyal and capable service to the state. They had begun to seize with enthusiasm the opportunities which the new age had created. They took part in trade; they built themselves houses like those of the missionaries; and they became staunch supporters of the church. Similarly, they threw themselves wholeheartedly into their political work. Even in the smallest details of their conduct they tried to follow the European models. A public prosecutor in 1826 is described, for example, as having worn a 'white oakum wig, which in imitation of the gentlemen of our courts of law, flowed in long curls over his shoulders, and a tall cap surmounting it, curiously ornamented with red feathers, and with variously coloured tresses of human hair.' To European visitors the results often seemed sufficiently bizarre; but beneath these superficial extravagances there lay an earnest resolve to live up to the standards of conduct expected of them by their missionary advisers. European visitors were continually amazed at the orderly and dispassionate consideration in the courts and the parliament of issues in which the private interests of the participants were closely involved. Though old rivalries had not been forgotten they were

henceforth fought out through the channels provided by the constitution.

The experience of Tahiti proved how quickly a new and untried system of government might obtain the support of nearly all the able and influential members of the community. But it proved also that, even so, such a government might be seriously undermined from within. The Tahitian government had proceeded very rapidly with its programme of Europeanization. Through all these changes the common people remained little altered. They conformed at first to the dictates of the new religion and the new laws; but they did so only from fear of punishment and persecution. Such grudging support needed little to turn it into active opposition. The first movement of revolt arose round the person of a former deacon of the church, who appeared before the people as a prophet proclaiming, in the name of Christ, a return to the old ways of living. The discontented flocked to hear him and attempted to put his teaching into practice. The public performance of the rites of the new sect was prohibited. But the influence of its teaching could not be thus easily destroyed; and the state of mind to which it had given expression continued to seek for outlets. (In the Pacific, as in other parts of the world where primitive people have come into close contact with Europeans, the emergence of such messianic cults has been one of the commonest forms of reaction against the too rapid spread of Western influence and ideas.) Europeans in Tahiti also did much to increase native opposition to the government. They created a mania for gin which a temperance law could not permanently curb. And the behaviour of drunken and unruly sailors and beachcombers in the vicinity of the port of Papeete set an example which soon spread to many of the younger Tahitians. This was to be the final test of the effectiveness of every native government in the Pacific: could it control the Europeans within its boundaries?

Where strong native governments so often showed themselves inadequate, disunited tribal authorities were almost entirely helpless. The problem of European lawlessness gradually forced the Western Powers to concern themselves with the affairs of the Pacific islands. From the time of the earliest trading and whaling voyages, as has been seen, there had been Europeans living in many of the islands. Shipwrecked, deserting and abandoned seamen, and escaped convicts in the main, they often used their influence to foment native wars and nearly always, when they were able, to the detriment of visiting

Europeans. They persuaded sailors to desert and organized attacks on ships and on parties ashore for wooding and watering (Plate 80). There was much in the situation in the Pacific in the first half of the nineteenth century which recalled the violence of the West Indies two hundred years before. There were many, in fact, who feared that beachcombers, Polynesians and adventurers from the unsettled countries of South America would turn to buccaneering. One or two incidents, notably the voyage of a former Chilean warship which was seized by her crew and taken on a pirate cruise, seemed to give substance to these fears. But piracy on any scale did not develop. Its failure to do so can be ascribed partly to the lack of important trade routes and the comparatively small value of Pacific trade; partly to the presence of missionaries, who had the ear both of the native rulers and their own governments; and partly to the activity, after 1820, first of British and then also of French naval vessels.

The real task was not to prevent the Polynesian islands from becoming pirates' lairs but to remove the more obnoxious beachcombers, to punish acts of brutality and generally to foster peaceful intercourse between Europeans and natives. Until after 1830 this responsibility fell entirely upon the British and, more specifically, upon successive governors of New South Wales. Action was first taken in 1801, when Governor King instructed the master of a colonial government vessel to remove certain troublesome beachcombers from Tahiti. During the following thirteen years several government orders were issued in Sydney, principally in an attempt to restrict the uncontrolled recruiting of Polynesians as sailors. Magistrates were appointed in the Society islands and New Zealand to supervise the working of these orders and to report on all misdemeanours by British subjects. An effort was then made to bring wrongdoers to justice. But no real success was attained. Even when the difficulty of procuring satisfactory evidence could be surmounted, conviction proved impossible because the validity of the government orders themselves remained in doubt and no court in the colony had full jurisdiction over crimes committed in the islands.

New South Wales officials and the missionary societies which had stations in the Pacific urged the Colonial Office, as a first step, to set up an effective Admiralty Court at Sydney and to give it special jurisdiction over offences committed on land in the Pacific islands. These pleas were at length heeded in 1823, when the political

machinery of the colony was being refashioned. The specially extended Admiralty powers which were then given to the new Supreme Court remained the basis of British extra-territorial jurisdiction in the Pacific for fifty years. But within a year or two of its enactment the new provision had proved its inadequacy. The two major difficulties of arresting offenders among the islands and of securing evidence remained untouched. The law made it possible to bring an occasional criminal to justice, though only at the cost of much effort and when conditions were specially favourable. It could contribute almost nothing to the maintenance of order where Europeans and natives were in permanent contact.

For many years action in regard to the Pacific islands was conceived as an extension of policy towards the Australian colonies. At first the islands had been thought of, at least in Sydney, as forming almost a part of the colony itself. The establishment in 1823 of a proper constitution for New South Wales, with its special provision for trial by the colonial Supreme Court of offences done in the islands, marked the beginning of a new phase: henceforth no responsible officials treated the Pacific islands as though they were in any sense under British protection. From this it was a natural development to regard them as independent; and it soon became a settled policy of Great Britain to give support to effective native governments wherever they existed and to encourage their emergence elsewhere. The natives themselves at first placed no great value on their independence: the rulers of Hawaii, Tahiti and northern New Zealand all made formal petitions for British protection and their action was later to be followed by very many others. But all the protection they could obtain was the promise of an occasional visit by a man-of-war to remove undesirable Europeans and to give advice on any difficult problems. In these circumstances, the independence of the more advanced islands began of necessity to take on substance. National flags were adopted (Fig. 88); consuls were received as the representatives of foreign Powers; and formal treaties were negotiated. The first Polynesian kingdom to obtain a full recognition of its independence was Hawaii in 1843.

But even before this time it had become clear that the real danger to a native kingdom was not in any defect in its status but in its lack of resources to defend itself against the armed forces of any Western state. In Tahiti, as has been shown, the government had experienced difficulty in controlling the sailors and beachcombers who congregated round the port of Papeete. This difficulty was greatly in-

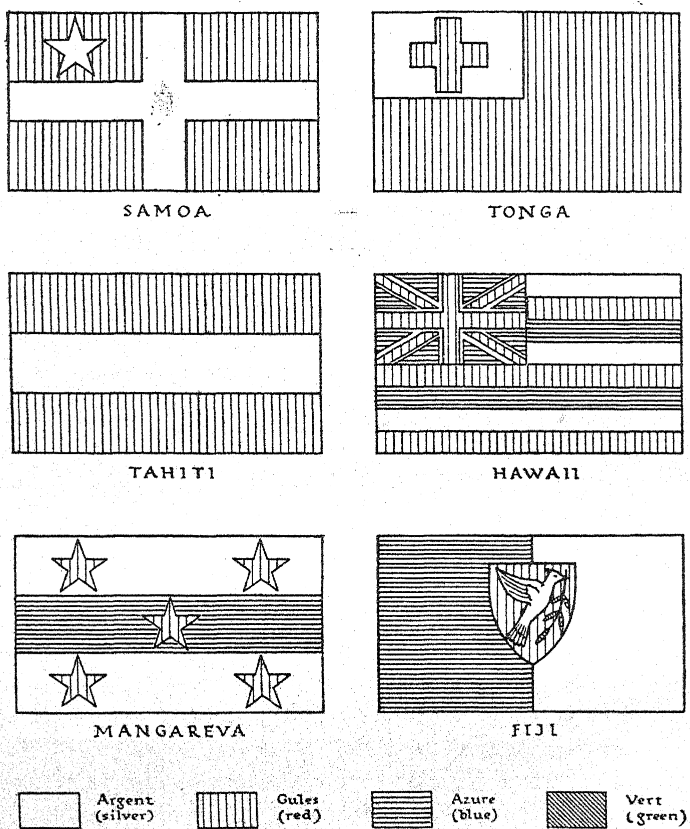


Fig. 88. Flags of the Pacific islands states

The flags of Samoa, Tahiti and Mangareva have been drawn from written descriptions only. Those of Tonga, Hawaii and Fiji have been copied from contemporary drawings. The sources used are as follows : (1) for Samoa, W. B. Churchward, *My Consulate in Samoa*, p. 62 (London, 1887) ; (2) for Tonga, Admiralty, *Drawings of the Flags of All Nations*, plate 36 (London, 1930) ; for Tahiti, C. S. Stewart, *A Visit to the South Seas, in the United States' Ship Vincennes, during the Years* 1829 *and* 1830 . . . , vol. II, p. 26 (London, 1832), and *Narrative of the Surveying Voyages of H.M. Ships Adventure and Beagle*, vol. II, p. 515 (London, 1839) ; for Hawaii, A. Macgeorge, *Flags : Some Account of Their History and Uses*, plate 6, no. 10 (London, 1881) ; for Mangareva, A. Du Petit-Thouars, *Voyage autour du monde sur le frégate La Vénus, pendant les années* 1836–1839 . . . *Relation*, vol. II, p. 254 (Paris, 1841) ; for Fiji, a watercolour drawing in the Museum of Archaeology and Ethnology, Cambridge.

creased after 1836 by the repeated attempts of French Roman Catholic priests to establish themselves on the island in defiance of the law and by the lawless behaviour of French naval officers and ratings, who scoffed at the British for obeying the behests of 'savage chiefs'. Many of the native leaders despaired of ever maintaining order without the backing of some foreign Power. Queen Pomare and her advisers therefore appealed again to Britain for help; but the answer was no more satisfactory than before. The way was thus prepared for the French consul and some native malcontents to force the Queen to ask for the protection of France. In September 1842, to prevent the execution of a threat of bombardment by a French warship, she yielded.

The independence of Tahiti was permanently lost, for Queen Pomare's act was in form a voluntary cession of sovereignty. To recognize the independence of a weak native state, therefore, only made it easier for a Western Power to annex it when it so desired. It was always possible to obtain the necesssary signatures to a treaty, and if this formality was observed no other Power was left with any legal ground on which to protest. The controversy which the French action aroused thus opened a new period in the political history of the Pacific. It was seen that if native states were to retain their independence, it must be by agreement among the Powers interested in Pacific affairs. The first of such agreements was reached by Britain and France (and adhered to by the United States) in regard to Hawaii in the following year.

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Chapter X

HISTORY, 1843-1939

The Broadening of Western Interests, 1843–75—The Expansion of Commerce and Agriculture : The Labour Trade : Political Development

The Extension of Western Control, 1875–1914—Control in Independent Areas : Annexatione by the Powers : Economic Development

The Modern Pacific, 1914–39

Bibliographical Note

THE BROADENING OF WESTERN INTERESTS, 1843–75

The Expansion of Commerce and Agriculture

In the years after 1840 the largest element in the trade of most of the South Sea islands was the supply of provisions to visiting whalers. Several of the ports which the whalers had previously frequented—especially the Bay of Islands and Papeete—were now much less busy. Old whaling grounds were being abandoned for new ; and, in both New Zealand and Tahiti, the recent political changes had tended to drive the ships away. But other island ports gained much new trade. By 1848 up to thirty whalers were calling in a year at Apia, on the island of Upolu in Samoa ; and at Pango Pango in Tutuila, as at the islands of Vava'u in Tonga, Kandavu in Fiji, Ponape in the Carolines, and Nauru, the number of callers was increasing also. By far the most striking gains, however, were those of the ports of the Hawaiian islands. In 1839 there had been 116 calls by whale-ships at Honolulu and Lahaina ; in 1846 there were 596. The number remained high for the next fifteen years.

The Hawaiian islands had become one of the great centres of the American whaling industry. The ships sailed from their home ports in New England, not expecting to return for perhaps three or four years. During that time Hawaii was their headquarters. They would go there for supplies or to carry out repairs or to unload cargoes of oil for trans-shipment to America. Some hundreds of Hawaiians enlisted each year as seamen on these ships. Thousands more made their livings by providing for the whalemen's needs. And a large majority of the European settlers were similarly engaged. In America it was claimed that the 'whaling-fleet made Honolulu'. But actually it did more than that : it firmly established the Hawaiian

islands as the foremost centre of European enterprise among the South Sea islands.

The only other spectacular change between 1840 and 1850 was the development of the sandalwood trade of the New Hebrides and neighbouring islands (Fig. 89). The existence of sandalwood on Eromanga, in the New Hebrides, had been known for some years. In 1829–30 traders had attempted to obtain it, but they had abandoned the venture because of the hostility of the natives and the apparent unhealthiness of the climate. By 1840, however, circumstances had changed. The exhaustion of Hawaiian supplies had caused a rise in the market price for sandalwood at Canton; and, at about the same time, there was a sudden influx of new capital into New South Wales. Sydney merchants, considering all possible forms of profitable investment, turned towards the sandalwood forests of the New Hebrides. Their first voyages were most encouraging; and within a year or two they had discovered further supplies in other islands of the group and also in the neighbouring Loyalty islands, in the Isle of Pines and in New Caledonia. Substantial trading stations were built on Aneityum and the Isle of Pines, and later in Tana and Eromanga. Sometimes these stations employed as many as fifty Europeans, as well as large numbers of natives. Their proprietors maintained agents, European, Polynesian or New Hebridean, in the various districts where sandalwood was obtainable. The wood was collected from these places by small schooners, which carried it to the central stations for shipment in larger vessels.

The trade was at its height between 1850 and 1860. Practically all the sources of supply were then known, from Espiritu Santo in the north to Noumea and the Isle of Pines in the south, and they were being worked by an increasing number of traders. Many fortunes were made. Sometimes the natives in whose district the wood was obtained were paid a nominal royalty, but often their rights were completely ignored. Wages given to the gangs of natives employed to cut the wood and bring it down from the valleys to the coast were almost fantastically small. The only heavy costs which the trader had to bear were those of maintaining his ships and shore stations and paying the freight to China. A cargo of 200 tons of sandalwood would have cost the trader £1,400 to £1,500 by the time it was landed at Canton; it would sell there, under the worst conditions, for about £2,500 and, with better fortune, for up to £10,000.

The trade thus offered great attractions to adventurous men.

At the same time, however, Europeans in the New Hebrides were quite outside the control of any effective government. Despite the sternest efforts of a number of leading traders to maintain good relations with the natives, the New Hebrides, Loyalties and New Caledonia became notorious for scenes of violence more brutal and more frequent than any which the Pacific had previously seen. Heavily armed trading vessels would open fire on natives who attempted to interfere with the despoiling of forests or looting of villages; the favour of one tribe would be gained by handing over to it members of another to be killed and perhaps eaten at a cannibal

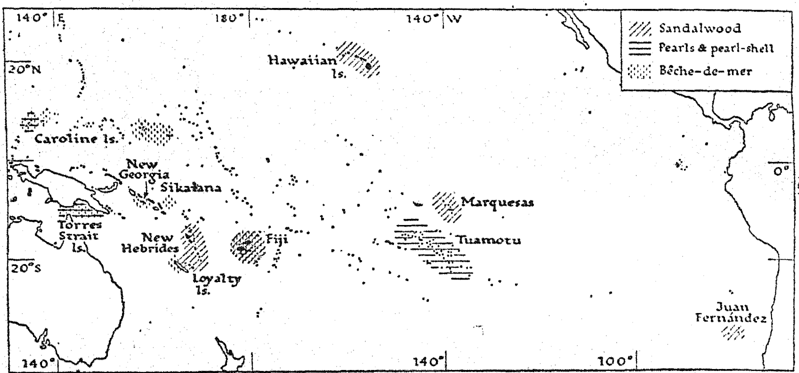

Fig. 89. The development of trade in the nineteenth century (I)
This map and the following one show in a very generalized way the parts of the Pacific which were affected by the growth of some of the more important forms of trade during the nineteenth century. Based on various sources.

feast; or one trading party would purposely stir up a quarrel when it had completed its task so as to spoil the opportunities of rivals. In retaliation the natives rose and attacked ship after ship. But at last the trade came to an end. Sandalwood was becoming scarce. In the New Hebrides what remained was not worth getting, so great had become the danger of conflict. Elsewhere activity declined to a trickle. As in Fiji fifty years before, the trade had been destroyed by the combined effect of increasing scarcity and native hostility to Europeans.

Slower in developing, but eventually of much greater importance, was the trade in coconut products. Raw coconuts had long been exported from the islands in small quantities. Several attempts had been made to find a market for coconut fibre. But more important than either of these was the beginning of trade in coconut oil. As

early as 1818 the missionaries of the L.M.S. in the Society islands had begun to collect the oil from their converts, as a contribution to missionary funds. They adopted the same practice later in other groups, and their example was followed by the Wesleyans. Unlike other missionary-inspired industrial schemes, this one made no heavy demand on the time and energy of the people. The oil was usually collected by placing the flesh of the nuts in the sun and leaving it to drain and then stored in bamboo, in an unused canoe, or in some other readily available container until a trading vessel arrived to collect it. Since it seemed to offer the natives an easy way of satisfying their steadily growing demand for European goods,

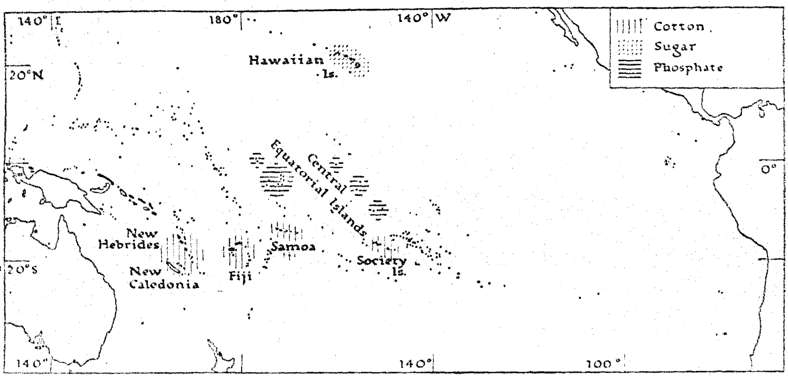

Fig. 90. The development of trade in the nineteenth century (II) For explanation see Fig. 89.

trade very soon sprang up independently of the missionary collections. For some years, however, the price of coconut oil on the European market remained too low to encourage traders to make it more than a minor interest. But after 1840 technical advances led to its use in the manufacture of soap and candles. The demand then became much keener. Merchants in the seaports on the edge of the south Pacific—particularly in Sydney and Valparaiso—became more interested; and traders in the islands began to concentrate their attention upon it.

The Hort brothers and John Brander of Tahiti especially did much to develop the trade. From their headquarters they sent out their schooners regularly to the Tuamotu archipelago and other groups of atolls where the coconut thrived, as well as to Samoa and the Leeward group of the Society islands. Development on a

really large scale was begun by the Hamburg firm of Godeffroy and Son. The Godeffroys established a depot in the Tuamotu archipelago soon after 1850, and another in Samoa in 1857. The latter, at Apia, at once became the centre of an extensive trading system. At Apia itself they built a large trading settlement, with stores and plantations, employing permanently by 1870 between thirty and forty Europeans and several hundred Polynesians, besides a large number of casual workers, both European and native. From here they built up a trade which embraced Tonga, Niue, Uvea, and Futuna in the south, and in the north the Tokelau group, the Gilbert and Ellice groups, the Marshalls, and the Carolines (where on the island of Yap they created another trading settlement). On almost every island where regular trade could be established they stationed an agent—most frequently of British or American nationality—to purchase oil. It was then collected in their small schooners and brigs and taken to Apia or Yap for later carriage to Europe.

Under the influence of the Godeffroys the port of Apia quickly attained as high a level of trade as the older Papeete; and Yap, from being visited only by an occasional whaler or trader for *bêche-de-mer*, became a busy centre of commerce. But till nearly 1870 the trade was held back by the inefficient native methods of extracting the oil. These were slow, and the product was generally dirty. To overcome this difficulty the firm began to purchase copra, or the dried flesh of the coconut, instead of oil. This demanded even less labour from the native, and it overcame the old problems of transporting the liquid oil, for copra could be packed in sacks. The oil could eventually be extracted much more efficiently by machine pressing. At first there was opposition by the natives of some islands to the innovation; but within a few years scarcely a trader was still buying oil. In 1859 the port of Apia had exported coconut oil to the value of £14,800; by 1875 the figure for oil had fallen to £400 but that for copra had risen from nothing to over £121,000. This change is symptomatic of the growth of trade in coconut products which followed the adoption of the new process all over the Pacific.

During the same years an industry which was temporarily of considerable importance had sprung up in the uninhabited islands of the central Pacific—Howland and Baker and the Phoenix and Line groups. These islands had often been sighted, and sometimes landed upon, by whalers; and in 1855 a sample of the greyish powdery material which lay in pockets on the surface of many of them had been taken back to the United States for analysis. It

proved to be phosphate. Companies were formed in the United States, and later in Australia, for the exploitation of this 'American Guano' (as it came to be known). Labour was imported, and in 1858 and following years work was begun on many of the islands (Fig. 89). By about 1870 peak production was passed, and most of the islands were abandoned during the following decade (though some were later to be reoccupied by other companies).

At about the same time as phosphate extraction was beginning, a new phase in the agricultural development of the Pacific islands had opened. Extensive experiments in plantation agriculture were made in many areas. Such development had long been envisaged. The sugar cane was native to many of the islands, while missionaries and settlers had shown that cotton, coffee, tobacco, indigo and various other crops grew readily in many places. Further, there had been the small-scale commercial production of sugar in Hawaii and the Society islands since shortly after 1830. The first impulse towards further endeavour sprang from the formation of the Manchester Cotton Supply Association in 1857. In compliance with the association's wishes the British government instructed British representatives in the Pacific to report on the cotton-growing possibilities of the islands. Early in 1859 the newly appointed consul in Fiji, W. T. Pritchard, arrived home with a deed signed by the chief Thakombau, who claimed the kingship of the whole group, offering to cede the islands to Britain. He discussed fully with the officers of the association the possibility of making Fiji an important producer of cotton. Shortly after Pritchard's return to Fiji, the British government sent out Lt.-Colonel W. J. Smythe to report generally on the advisability of accepting Thakombau's offer, and Dr Berthold Seemann, a naturalist, to study the economic possibilities of the group, especially with regard to cotton growing. Smythe reported against acceptance. But Seemann was exuberantly enthusiastic, and in official and unofficial quarters urged settlement and annexation. The government determined to decline the offer; but already prospective cotton growers had begun to arrive in Fiji. Over the next ten years cotton drew more and more settlers to Fiji; and finally, in 1874, brought about British annexation.

This publicizing of the attractions of Fiji had proved so effective, however, because of an event outside the Pacific which suddenly changed the prospects of plantation agriculture throughout the South Seas. In 1861 the American Civil War had broken out. The north lost its supply of sugar from the southern states, and the cotton

supply of all the industrial Powers was greatly disrupted. The Pacific islands were among the places to which men looked for replacement of what had been temporarily lost. Hawaii suddenly found itself with a market ready to take all the sugar it could produce. Exports rose from a little over 1,000 tons in 1861 to nearly 7,000 tons in 1865. In other groups the principal effect was the rapid establishment of cotton plantations. In Samoa, for example, cotton began to be exported in 1864; eleven years later the port of Apia handled £45,000's worth. In Tahiti there were a number of small-scale attempts at planting, and in addition a very large plantation was established at Atimaono on the south coast by an English company. By 1870 cotton, valued at £62,000, made up almost two-thirds of the French colony's exports of local produce. In Fiji cotton had replaced coconut oil as the principal export as early as 1866. Four years later the industry was worth over £90,000 to the group.

The close of the American war in 1865 had not destroyed the industries which its outbreak had helped to bring into being. In the Hawaiian islands the newly expanded sugar industry was able to survive a period of depression and be ready to advance again ten years later when a reciprocity treaty opened the American market without restriction. In other parts of the Pacific there was a similar belief in the future of the sugar industry. In the colony of Queensland it became established in the later 'sixties (as cotton had become established there during the Civil War years); and in many of the islands of the south Pacific active developments only awaited the acquisition of adequate capital and the solution of political difficulties.

The fall in cotton prices which followed the restoration of American plantations was not seriously felt in the Pacific until 1873. In 1870 and 1871 especially there was a very rapid expansion in the area under cotton. This was due principally to the activity of recently arrived settlers, from Australia and New Zealand, though in a few islands—notably Niue—there was also some cultivation by natives. Most of the settlers went to Fiji; but a few took up land in other areas, including the Society islands, Samoa, New Caledonia, and the more backward New Hebrides. At this time it appeared to most men who had any close acquaintance with the affairs of the Pacific that a new era was beginning. In most of the larger islands, it seemed, the native populations would before long be replaced largely, if not completely, by flourishing communities of white settlers.

In 1870 the total number of Europeans in the Pacific islands was probably round about 15,000. Of these 5,000 were in the Hawaiian islands and 2,000 in Fiji. In New Caledonia (which had been annexed by the French in 1853) there were about 1,600 'colonists' in addition to a rather larger number of officials and convicts. The next most important centre of white settlement was Tahiti. Elsewhere there were no groups of more than a few hundred, though in one or two places (notably in Samoa) the scope of the settlers' activities in the economic sphere gave them a position of great power and importance. Judged by the standards of long settled countries in the temperate zones, these figures seem minute. But their true significance can best be seen by comparing them with those for other tropical regions. The white population of the Hawaiian islands, for example, was then between a quarter and a third of that of Kenya today, while that of Fiji was slightly larger than the present white community of Nyasaland (and the two East African territories have economic systems of a roughly similar type to those of the two groups of islands).

Since the expansion of sugar and cotton planting had begun so recently, European settlement still centred upon the seaports. The principal of these were Honolulu in the Hawaiian islands, Papeete in Tahiti, Apia in Samoa, Levuka in Fiji, and Noumea in New Caledonia. Of these Honolulu was easily the most important. Its export trade, with sugar as by far the largest item, was more than twice that of any of the others. Honolulu, and consequently the country as a whole, was dominated by Americans. As merchants, politicians, clergymen, schoolmasters and journalists, they filled a big proportion of all the most important positions. Despite the presence of a royal court and a considerable (though steadily declining) native population, Honolulu seemed in some ways almost a Middle Western community transported to a tropical island. Far different was Papeete. Here French officials, English merchants and Europeanized Tahitian chiefs formed the leaders of society. In social life Papeete, with its receptions at the beautifully appointed Government House and at the home of Queen Pomare, attempted an elegance found nowhere else in the South Seas. Economically at this time it depended principally upon its cotton export and its trade with the surrounding islands. Most of the foreign trade of the Tuamotu, Leeward and Austral groups was carried on through Papeete; and locally-owned schooners still traded as far afield as Samoa. Noumea, in New Caledonia, the other French centre in the

Pacific, was only just beginning to develop commercially. Here, too, many of the traders were British. The government was at this time attempting with some success to attract new settlers; but its dominant concern was with the convicts who had been arriving in the colony since 1864. Apia, in Samoa, had probably the smallest white population of any of the principal centres. It was, of course, dominated by the firm of Godeffroy; and, through their activities, it became in the 'seventies second in importance to Honolulu among Pacific islands ports. The visitor to the Pacific in 1870 would, however, have been most astonished at the activity of Levuka. There, stores, hotels, and grog-shops were constantly thronged. Every shanty seemed to be given up to commerce. All hours were hours of business. The price of cotton was still high. The planters were ready to accept new credit on any terms. And ships from Australia and New Zealand were constantly arriving with parties of new settlers. Men discussed, in glowingly optimistic terms, the future of cotton, coffee and sugar, and speculated on the political future of the islands. The atmosphere was that of a gold-rush town. The local settlers expected Levuka soon to displace Honolulu as the principal town in the South Sea islands.

Apart from these main centres there were embryo towns, usually with stores and public houses, at a number of other places in Hawaii and Fiji, at Nuku'alofa and Neiafu in Tonga, at Uturoa on Raiatea, and on the island of Yap. Outside these semi-urban areas Europeans, apart from missionaries, fell principally into three groups—planters, trading agents and beachcombers. The last group was a declining one. The beachcombers had been largely driven out of the more advanced regions; and even in an island as far removed from the main spheres of European activity as Rotuma only one or two remained out of about seventy who had been living there forty years before. The survivors were being steadily pushed out into the smaller atolls where the sheer lack of resources had so far prevented the growth of trade. Wherever trade was well begun their place had been taken by regular trading agents. These men also generally maintained close relations with the native people amongst whom they lived. Many of them had native wives and large families of half-caste children. A lot of them, like the beachcombers, had formerly been sailors; but they were a more reputable class of men. The merchants whom they represented demanded of them at least the temperance and industry necessary for the successful carrying out of their work. And many traders—men, perhaps, who had

retired to the South Seas because of private misfortunes—came much above these minimum requirements.

The planters were an equally varied class. Those in the Hawaiian islands were, in the main, typical American business men. In Fiji however, they formed no such well-knit group. A large proportion of them were farmers, lawyers, doctors, and shopkeepers from the Australian colonies and New Zealand. A number were half-pay officers of the British army or navy. There was also a group of Americans and a few Germans. Elsewhere in the Pacific islands the planters usually belonged to one or other of these groups. As in newly settled countries generally, there was an unusually large proportion of adventurers, eccentrics and misfits. Men like William Stewart, the manager of the Atimaono plantation in Tahiti, who by shrewd (and often unscrupulous) contriving made even the governor of the colony his tool; or De Courcy Ireland, the quick-tempered society leader who fled to Fiji after attacking a cordon of police in Melbourne with a riding whip; or Dr. Macartney, former Anglican clergyman, barrister and colonial politician, who went there seeking a cure for dipsomania—all these were representatives of not uncommon types. In Fiji living standards were likewise at their most varied. At the top of the scale were a few men with private incomes to whom profit or loss in the running of their plantation was not a matter of urgent importance. They possessed large houses and well-stocked gardens and adequate domestic staff (including often an Indian or negro cook); and they regularly supplemented the limited food supplies of their farms and the Levuka stores by extensive private importations. The majority of planters, however, were comparatively poor men, heavily in debt to the Levuka merchants. Their houses were generally built of reeds by the natives; and their staple fare was salt beef, ship's biscuits, sometimes milk and poultry, and such fruit and vegetables as the country provided. Beneath them came a small group of 'poor whites', men who had arrived with little or no capital of their own and had gambled too heavily on the likelihood of a further rise in cotton prices. Their standard of living was sometimes little above that of the natives around them. Their wives and children were often short of even the bare necessaries of survival for white residents of the tropics. But important as these differences of national and social origin and of living standards are as a basis of classification, they are in one respect superficial. The fundamental division all over the Pacific was between those planters who could, and those

who could not, obtain adequte supplies of labour for the economic working of their plantations. With sufficient labour there was a chance of obtaining a return on capital; without it any venture was condemned to certain failure. To satisfy this need, as well as that of territories bordering on the Pacific, an extensive traffic had sprung up in the recruitment of men and women in the less settled islands for work on the plantations.

THE LABOUR TRADE (Fig. 91)

For over half a century before the rise of an organized labour traffic in the 1860's natives of the Pacific islands had been employed by Europeans. Thousands had served as sailors alone; and a large number had also been engaged as divers on pearling expeditions or in cutting sandalwood or collecting *bêche-de-mer* in islands far from their homes. Others—especially Hawaiians—had been taken to various islands of the central Pacific to dig phosphate. Still others had worked in conditions even less readily distinguishable from those of the later plantation labourers. A few Maori from New Zealand, for example, had been employed as shepherds in New South Wales almost since the beginning of the century. Two shiploads of Loyalty islanders had been brought to the colony in 1847 for the same purpose. And by 1860 settlers in both the Society islands and Fiji had begun to employ natives from other island groups.

All these forms of employment lent themselves readily to abuse. Natives in a strange land, or on board ship, were almost completely at the mercy of Europeans. From the earliest years many acts of brutality were brought to light. But, although criticism had sometimes been violent, it had seldom been long sustained. For this there were two reasons. First, outrages had been sporadic rather than continuous; and, second, the Western nations had been so much absorbed in the struggle against slavery that they had remained somewhat deaf to other calls for help. The native labour problems of the Pacific forced themselves upon the conscience of Europe only when atrocity stories began to pour in and when conditions approximating to slavery had actually come into existence.

This situation first appeared when shipowners of Callao began collecting Pacific islanders for work on plantations and in phosphate quarries in Peru. The country stood in great need of a supply of cheap labour. For many years the possibility of obtaining men

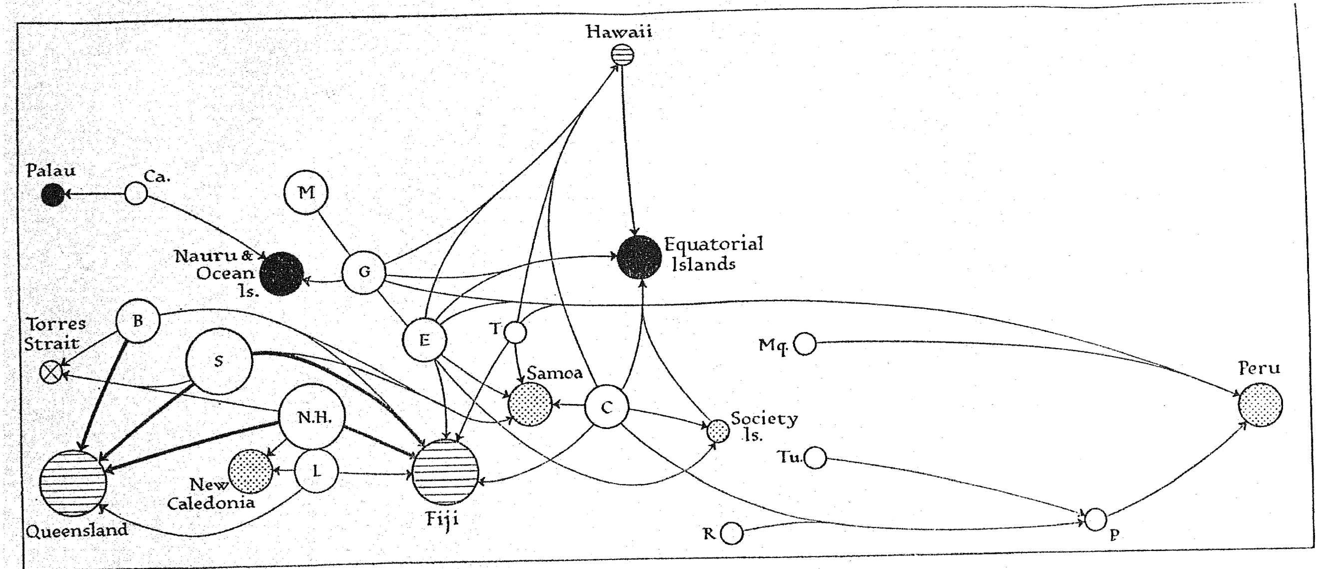

Fig. 91. Pacific islands labour flow

This cartogram illustrates the movement of native labour in the Pacific islands area since 1860. The size of the circles which represent the various island groups indicates roughly their importance as areas of recruitment or of employment. Detailed explanation is as follows:
Areas of recruitment: ○; Ca., Caroline islands; B, Bismarck archipelago; S, Solomon islands; M, Marshall islands; G, Gilbert islands; E, Ellice islands; N.H., New Hebrides; L, Loyalty islands; T, Tokelau group; C, Cook islands and Niue; Mq., Marquesas; Tu., Tuamotu archipelago; R, Rapa; P, Easter island.
Areas of employment (principal occupations): ⊜, sugar cultivation; ◌, cotton growing and other plantation agriculture; ●, phosphate extraction; ⊗, pearl and *bêche-de-mer* fishing.
Based on contemporary books, printed official reports, and manuscript sources.

from the islands had been discussed. The experiment was tried in 1862. The first ship returned with over 280 'colonists' from Penrhyn island. Her success caused a flurry of activity. Within a year between two and three thousand Polynesians were removed from their homes. The labour vessels were active all over the Eastern Pacific—in the Tuamotu archipelago, the Mangareva group, and the Marquesas; at Easter island; in the Austral, Cook and Tokelau islands—and they reached as far west as Niue and the Ellice group. The recruiters claimed all the so-called 'colonists' as voluntary emigrants; but truer accounts of their activities were very soon received. The French authorities at Tahiti, and also missionaries and others, made stern protests; and natives who had lost their relatives and their subjects sent out agonized pleas for protection. Force and fraud had been everywhere used; some islands had been almost swept bare of their inhabitants; and the Peruvians had recked nothing of the loss of life which their raids had entailed. The condition of those who arrived in Peru spoke no better for their treatment on board. When it became evident, too, that hundreds of them were dying under the treatment they received from their employers, the experiment stood condemned on every count. Under the leadership of the French *Chargé d'Affaires*, the diplomatic corps at Lima brought pressure to bear upon the Peruvian government, which, in April 1863, issued a decree abolishing the traffic. But the final tragedy was yet to come. About 850 of the immigrants were brought together for repatriation. They sailed from Callao on two ships. On both about half died from disease during the voyage; and the remainder, ill and under-fed, were dumped in the Galápagos and at Rapa respectively.

Circumstances, however, proved more powerful than sentiments. The rise of plantation agriculture in the Pacific islands and the colony of Queensland created there a demand for cheap labour no less urgent than that of Peru. Almost at the same time as Peruvian 'slavery' was being denounced the labour problem was being discussed all over the Pacific. Except in Queensland, where there was the added possibility of reviving convictism, the discussion everywhere took much the same form. Could indentured labourers be obtained from China or India, or must the planters rely on the less efficient, but more readily available, South Sea islanders? Hawaii had already brought in several hundred Chinese to work in the canefields, and Tahiti was shortly to obtain about a thousand for the great plantation at Atimaono. But, in general, the day of the Asiatic indentured

labourer had not yet dawned in the Pacific. Lack of capital forced the planters to be content with ' kanakas '.

The labour trade came into existence almost simultaneously in the five principal island ports—Honolulu, Papeete, Apia, Levuka and Noumea—and at Brisbane. It grew most rapidly in Fiji and Queensland. Between 1863 and 1868 about 2,700 labourers were imported into the latter area and rather over a thousand into the former. After that it increased more vigorously, so that in the early 'seventies ten to a dozen vessels, each of from about 70 to 150 tons and carrying from 50 to 120 men, were engaged in supplying Queensland and probably about an equal number in supplying Fiji. The ships were fitted up like old-time slavers. The ' passengers ' were accommodated in the hold, which was sometimes provided with shelves for them to lie on and sometimes not. Here they might have to remain for up to two months, while the ship cruised from island to island seeking fresh recruits, or during a prolonged voyage towards their destination against contrary winds. A labour vessel would normally make about two voyages in a year.

At first the principal recruiting grounds for the Queensland and Fijian markets were the New Hebrides and the adjacent Loyalty and Banks groups. The men of the island of Tana, in the southern New Hebrides, were always regarded with special favour, for though, in the complacent language of the whites, ' sunk in utter barbarism ' they were ' docile, intelligent, and active '. The New Hebrides as a whole were regarded as providing the best labour. But recruiting was often difficult and dangerous. For this reason some Fijian ships tried other regions. After 1866 they were specially active in the Gilbert and Ellice islands, where they made contact with labour vessels from Tahiti and Samoa. The ' Tokalaus ' or ' Line Islanders ', as the people of all the islands from the Marshalls to the Tokelau group were vaguely termed, were much easier to recruit. And, once arrived in Fiji, they showed much less of the active rebelliousness which was considered the great fault of men from the New Hebrides. However, they lacked the physical stamina of other groups of plantation labourers. The Fijian planters therefore began to consider other sources. They turned increasingly to the Solomon islands. The men of the Solomons were regarded as the most ' savage ' of all labourers, ' treacherous to the last degree ', but they soon grew ' fat and sleek ' if well-fed, and they were strong. Queensland ships, some from Samoa and others from the *bêche-de-mer* and pearling stations in Torres strait, followed them there, so that within

a few years the Solomons stood second to the New Hebrides as a source of indentured labour.

The protest which the Pacific islands labour traffic drew from naval officers, missionaries and humanitarians generally is to be explained by reference not to any general objection to the movement of labour from economically backward to more advanced areas but to the particular circumstances in which the traffic was conducted. Because of this most of its opponents—including the Anglican Bishop Patteson, who later was killed by natives of Nukapu, in the Santa Cruz islands, in retaliation for the depredations of a labour trader—were willing to concede at first that regulation rather than suppression was needed. This rendered their efforts in part ineffective, since the abuses to which the traffic led went so deep as to be inseparable from it. Suppression was eventually proved the only remedy, but not until many years had passed.

The worst of all evils were those connected with recruiting. A visitor to the New Hebrides in 1872, F. A. Campbell, attempted a quantitative analysis of the various ways in which recruits were obtained. His figures are a fair indication of conditions existing everywhere at that time. He believed that about 10% were taken by force, 20% 'obtained by deceit', and another 20% forced to go by chiefs or relatives who had sold them to the traders. The remaining 50% could in some respects be considered free emigrants. But he sub-divided them as follows: 15% returned labourers who re-engaged themselves in disgust at finding that they had lost their place in their community through their previous absence; 5% who voluntarily accompanied chiefs taken by force or fraud; 15% who emigrated because of defeats in war (and the labour trade, directly or indirectly, caused many of these wars); and, finally, 20% who genuinely wished to go because of curiosity or desire for gain.

Many strategems were resorted to in order to obtain men by force. Often the natives were induced on board and then forcibly kept in the hold while the ship put to sea. Another method commonly used was that of seizing them from their canoes. This reached its greatest refinement in the hands of the officers of the *Carl* of Melbourne. They first encouraged canoes to come alongside; then, heavy pieces of iron (attached to the ship by long ropes, so that they could be salvaged) were dropped on to them to upset or smash them; finally, the occupants struggling in the water were dragged on board. Similarly many subtle kinds of fraud were developed. One of the most damaging was the attempt to disguise the ships as well-known

missionary vessels. All these actions, however, could at least be brought within the cognizance of the law. Proper supervision would make it impossible to commit them without some risk of punishment. The abuses which arose during genuine negotiation with the native peoples could not, on the contrary, be so simply dealt with. From the point of view of the chiefs, recruits were obtained legitimately when the tribe was compensated for their loss—in other words when they were 'sold'; voluntary emigrants, on the other hand, were often said to have been 'stolen'. This view was totally at odds with that taken by naval officers and Europeans courts. The traders, making the best of both worlds, submitted to the code of neither. They 'bought' and 'stole' and were always ready to produce evidence that they did neither.

On board the ships men from different islands—often unable to speak one another's language—were thrown together in the hold. Often they fought among themselves, and sometimes there was fighting between them and the officers and men of the vessel. On many occasions there was loss of life. Generally the conduct of master and officers was a contributory cause of these conflicts, but it was not so in the most disastrous of them all. This was the mutiny on the Tahitian barque *Moaroa* in 1869. Her master was no ruffian, but one of the most respected members of the commercial community in the Society islands, yet he and several members of his ship's company and about 250 'Line Islanders' lost their lives. The labour trade, in other words, could only be carried on by methods which led, despite the personal integrity of those engaged in it, to injustices and fatal misunderstandings.

The employers of native indentured labour were often abused by missionaries and others in the same terms as the recruiters. Such criticism was fiercely resented (and with good reason). There were, of course, brutal employers; but the great majority intended to see their employees fairly treated. The real case against the indentured labour system lay in its tendency to create among the employers the outlook of a slave-owning class. For despite the important differences—especially the undertaking to return the labourers to their homes at the end of a period of service—the labourers came to be regarded more as chattels than as human beings. Advertisements in Levuka, for example, would announce the 'sale by auction' of 'prime Tanna men'. And in all the areas where imported labourers were employed they were treated mainly as instruments of production: housing, for instance, had merely to be good enough to keep them in

a fit state for work; or, again, a high death rate among them was a factor to be considered largely in economic terms. That they might have a complex personal life was something of which the average planter remained largely unaware. If he discussed their personal affairs at all he did so only in the language of the farmyard. The social structure of northern Queensland and Fiji, where 'kanaka' labour attained its greatest importance, took on quite perceptibly the complexion of the slave-owning planter communities of the West Indies a hundred years before.

In Australia and New Zealand important sections of the public were opposed to the continuance of the labour trade under any conditions. They believed that the interests of white labour were endangered by the growth of a plantation economy in both Queensland and Fiji, based upon what they described as a 'frightful system of slavery'. At the same time, there was no satisfactory answer to the question which the planters themselves had been the first to ask: where else could they obtain the labour necessary for cotton and sugar planting? Thus the first attempts to remove abuses were carefully devised so as to interfere as little as possible with the continuance of the trade.

Action was taken first in Fiji. From the very beginning of the organized importation of labour, leading settlers arranged with the British consul that vessels should obtain a licence from him before setting out on a labour cruise. On their return recruits were to be brought to the consulate for examination, and all agreements between them and their employers were to be filed there. For several years this system successfully prevented most of the grosser abuses. But it relied for its effectiveness upon the exercise of social pressure. When large numbers of new settlers began to come to the islands (after 1869), and the demand for labour became more pressing, it broke down. Something much stronger was needed once so many stood to gain from the continuance of unscrupulous practices.

Meanwhile, the government of Queensland had been pressed into action by the British government and by local public opinion. In 1868 it passed an act to bring the traffic among the islands and the treatment of labourers within the colony under a broad system of regulation. The act, however, was almost a dead letter. This was partly the result of ignorance or corruption among the officials administering it, but much more of faults in the act itself. The Queensland government took no further legislative action, however, until two and a half years later, when it enacted that labour ships

should carry a government agent charged with the duty of supervising relations between the ship's company and native recruits. This change undoubtedly reduced the number of major atrocities. But the agents themselves were often men of poor character and, in any case, their lives became almost unendurable if they differed too frequently from the officers of the ship.

The most effective measures were those of the United Kingdom government. From the first occurrence of serious conflict, British naval officers in the Pacific took a strong stand. Their reports, along with the despatches of colonial governors and the petitions of missionaries and others, persuaded the authorities that the labour trade was a matter for Imperial action. The murder of Bishop Patteson in September 1871 gave the problem a new urgency, In the following year an act was passed prohibiting British vessels from engaging in the labour trade except under licence from a colonial government or a British consul. Colonial courts were given increased powers to deal with kidnapping, and for the first time the evidence of natives 'ignorant of the nature of an oath' was made admissible. At the same time the Admiralty had a number of schooners built in Australia to undertake regular policing duties. These reforms greatly reduced many of the worst evils. But they were to prove inadequate in various ways. Thus in 1875 a further measure was passed to give Vice-Admiralty courts jurisdiction to try and condemn the ships engaged in illegal activities and also to provide increased powers of dealing with crimes committed among the islands. A year earlier Fiji had been annexed. In 1877 the governor of the new colony was appointed to the additional office of High Commissioner and Consul-General for the Western Pacific. These changes introduced a new phase in the development of British policy in the Pacific. In the history of the labour trade they opened a new era in which stricter supervision led progressively towards extinction.

Political Development

British action regarding the labour trade is indicative of the general policy of the Powers in the Pacific islands in the years from 1840 to 1875. The period had opened with the British annexation of New Zealand and the establishment of a French protectorate over Tahiti; but this had not meant that there was any general desire to acquire new territories (Fig. 92). Britain and the United States had been concerned mainly in preventing Hawaii and Samoa from sharing

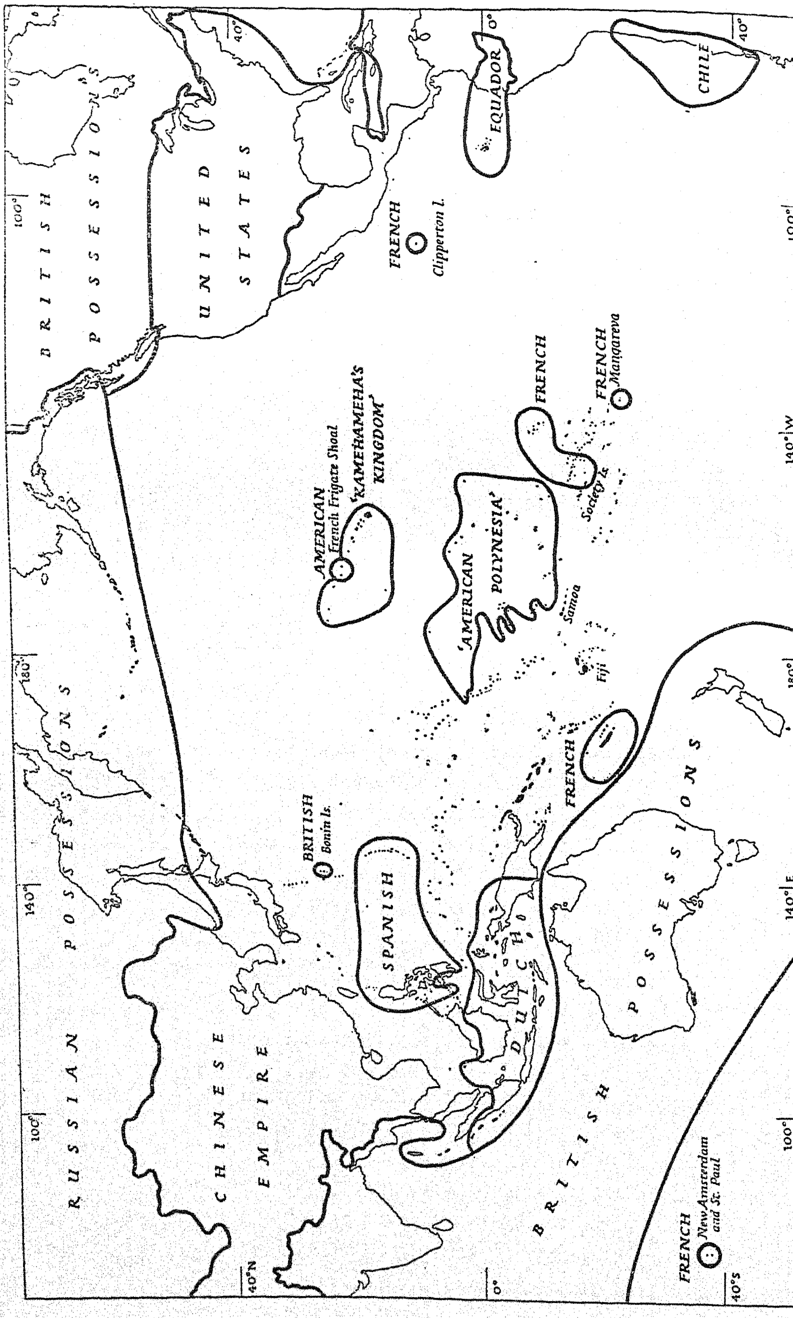

Fig. 92. A German view of political control in the Pacific area in 1859

the fate of Tahiti, and, at the same time in avoiding the necessity for more positive action themselves. In 1845 the expansionist policy of France almost came to an end. Henceforth, for thirty years. Western governments were principally desirous of protecting the personal and economic interests of their subjects in the islands and of establishing peaceful relations between Europeans and natives.

To achieve these ends, ships-of-war were sent with increasing regularity on cruises among the islands. Their work was, in general terms, to consult with consular representatives and other white residents and native rulers; to remove undesirable white men; and to punish native ill-treatment of missionaries or traders. In the more advanced islands they usually found many disputes awaiting settlement. These often were extremely trying to their skill and patience. Catholics and Protestants, Frenchmen and Englishmen, or traders engaged in bitter commercial rivalry, would bring forward wholly irreconcilable testimony; and native chiefs would frequently seek to throw responsibility for a murder or the seizure of a ship on to some innocent tribe against whom they bore a grudge. Faced with such difficulties officers responded in many different ways. The French had argued since the age of exploration that the only way to gain the respect of native peoples was to be severe, allowing not even the smallest wrong to go unpunished. Now, in the Pacific, they had a further motive for practising such a policy. They found great hostility to France nearly everywhere that English Protestant influence had become established. It was a consequence of French action in Tahiti and of the Roman Catholic invasion of Protestant mission fields. As a result they tended always to accept the complaints of their countrymen—whether missionaries or traders—and

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Fig. 92. A German view of political control in the Pacific area in 1859

Redrawn from a map in *Mitteilungen aus Justus Perthes' Geographischer Anstalt . . . von Dr. A. Petermann*, Tafel 9 (Gotha, 1859). This map illustrated an article by E. Behm, 'Das Amerikanische Polynesien, und die politischen Verhältnisse in den übrigen Theilen des Grossen Oceans im J.1859', *ibid.*, pp. 173–94. The map gives a general impression of political interests and control in the Pacific area at the time it was published. Several of the island areas shown were not formally linked to the Power to which possession is attributed. The proclamation of British sovereignty in the Bonin islands by Captain Beechey in 1826 had never been confirmed; and, though many of the islands in the area marked as 'American Polynesia' were being worked at the time for phosphate by American interests, no formal acts establishing American sovereignty had been taken. The map shows how many of the island groups remained at this time independent of external control; it may be compared with Fig. 95, showing sovereignty in 1914.

to inflict severe punishment on native offenders. The English and the Americans were less consistent. A few officers showed the same readiness to accept the distorted tales of Europeans and to carry out excessive reprisals against natives. A smaller number so despised their fellow-countrymen in the islands—even consuls—that they dismissed their complaints with open contempt. But most of them exerted a most beneficial influence, which was welcomed by both Europeans and natives. This was particularly true of British officers, who, aided by the preponderance of British missionary and commercial influence over so much of the Pacific, were able to establish closer relations with the natives than were many of those in the service of other Powers. Together with the work of English missionaries, the regular visits of vessels of the Royal Navy were the principal factors in creating a feeling among so many native peoples in the Pacific that Great Britain was their natural protector.

Britain and America were further represented in many areas by consuls; and France, although her interests in the Pacific were largely confined to her own colonies, maintained a consulate at Honolulu. Several other European states—notably Denmark and the Free City of Hamburg (and later the German Empire)—also had representatives in the South Seas. These officers dealt with political as well as commercial matters, for, except at Honolulu in later years, there were no formal diplomatic representatives of any of the Powers. At Tahiti, under French administration, and in Hawaii, where the native government was constituted on Western lines, the work had few peculiarities. Elsewhere, however, in less advanced areas such as Samoa or Fiji, the position of a consul was greatly different. In such places the office was often an honorary one conferred on a local settler, who might do no more than send an occasional report on local conditions to his government. If, however, the consul were a salaried officer, the calls on his time were unending. Disputes between settlers and natives, between residents and visiting ships, and between captains of vessels and their crews were continually occurring. Frequently, Europeans of several different nationalities were involved, so that if there were more than one consul in the area a further complication was often added to the problem of reaching a settlement. Beyond these serious disputes were the quarrels and difficulties of the white 'rabble'. Drunken brawls had to be stopped before they became the basis of lasting feuds; and destitute and shiftless men had to be turned into workers—or else deported.

The consuls had to attempt to maintain justice and order, owing

to the inadequacy of native governments. The means of their doing so were extremely few. British officers could usually expect help from a warship on its regular annual cruise. Their American colleagues were less fortunate; a naval vessel was unlikely to visit them except in response to a specific request. British subjects deported from the islands could be tried for their offences in New South Wales; but convictions were seldom obtained—often because juries refused to regard seriously offences against mere 'savages' In this respect the Americans possessed, on paper, more adequate powers, since under an act of 1860 they themselves were authorized to arrest and try American subjects. In fact, however, as they lacked any means of enforcing their decisions, they were no better off.

Such limited action was sufficient only when white residents were few. As soon as settlement increased there was risk of a complete breakdown of order. Thus, in Samoa and Fiji from the 'fifties onwards it was urged that Britain or America should intervene more actively—by annexation or the establishment of a protectorate. As neither nation was yet ready to assume the responsibility, the consuls were forced to act beyond the formal limits of their authorities. In Samoa they collaborated in forming a 'Court of Foreign Residents', and in Fiji remarkable work was done by W. T. Pritchard, the first British representative in that group. After his return from his visit to England in 1859 (p. 295), Pritchard believed that a regular colonial government was bound to be established in the islands within a year or two. In the meantime, he determined to maintain order. He persuaded the chiefs to give him full control over the affairs of the whites and jurisdiction in disputes between them and Fijians. With this authority, and the expenditure of great energy and quite unusual skill, he achieved what other foreign representatives from the time of Busby, the British Resident in New Zealand in the 'thirties, had unsuccessfully attempted; he maintained what was in effect a government, without the aid of any organized force to back it up (vol. III, pp. 133–4). After two and a half years Pritchard learnt that the British government had decided not to annex Fiji and that he had been recalled.

To the government it seemed that Pritchard's activity was creating a situation in which annexation would be unavoidable. His successor was, therefore, carefully instructed as to the limits of his authority. Circumstances soon forced him to go beyond it; and, with a new influx of settlers and the growth of the labour trade after about 1867, the acting-consul J. B. Thurston was forced to extend the influence

of the office almost as widely as Pritchard had done. In 1869, when another appointment to the consulship was being made, the government determined again to stop the drift towards annexation; the instructions of the new consul, informing him of the limits of his powers, were made public. From that time consular jurisdiction was patently insufficient to maintain order between Europeans and natives in Fiji. In Samoa the situation was very similar.

For this reason it was highly desirable that, wherever Western

Fig. 93. George (Siaosi) Tupou I of Tonga
After a portrait in A. H. Wood, *History and Geography of Tonga*, p. 51 (Nuku'alofa, 1932).

penetration was far advanced and no Western Power was willing to set up an administration, there should exist a strong native government. In both Fiji and Samoa it was hoped that this could be brought about. The two most notable native governments effectively functioning at this period were those of Hawaii and Tonga.

In Tonga the government was strong and stable. This was primarily a consequence of the strong personality and remarkably long life of the King, George Tupou (Fig. 93), who provided and enforced a code of laws and established a land system which placed ultimate ownership in the hands of the Crown. Partly, it was a result of the relatively limited resources of the group, for this,

together with the Crown control of lands, kept down the number of European settlers.

Government in Hawaii was much more complex because of the existence of the powerful settler community. In 1839 a Declaration of Rights had been published, and following this a series of sweeping reforms was undertaken during the next fifteen years. A parliament was established in 1849 consisting of a council of chiefs (later known as the House of Nobles) and an elected Representative Body; the laws were codified; a series of Organic Acts provided a statutory basis for the executive and judicial branches of government; and the old quasi-feudal system of land tenure was replaced by freehold. These reforms were undertaken, needless to say, principally to enable the government to deal more effectively with Europeans. Great gains resulted. The Powers began to treat Hawaii as a sovereign and fully independent state; and, internally, relations with the settlers became more orderly. But there were corresponding losses. To Europeans the new system was readily comprehensible; but it was not so to the majority of native Hawaiians, who thus failed from mere lack of knowledge to enjoy their full rights. Similarly, European influence increased in the government itself. Foreigners were appointed as ministers, judges, and representatives abroad, and the foreign community gradually increased its political rights until it came to exercise a dominating influence in the parliament.

The acquisition of California and Oregon by the United States in 1846 and the discovery of gold in the former territory two years later revolutionized the position of the Hawaiian islands. The rapid growth of settlement on the Pacific coast drew the group within the orbit of American expansion, just as the development of the Australian colonies and New Zealand was making British intervention in many parts of the south-western Pacific equally probable. Within a year or two the annexation of Hawaii was being discussed in the American press.

The centre of the movement for annexation to the United States was in the islands, where Americans had long been the most influential group within the foreign community. Annexationist sentiment reflected their determination to improve their position still further; they desired a free market for their sugar and complete control of the internal government of the islands. The first object, however, could also be obtained by a trade treaty and the second by gradual penetration of the local government. In practice, annexationist

energy was largely turned into these latter channels. Gradually the missionary party—the protector of native rights—was driven from power and replaced by supporters of the traders and planters. At times settler political dominance seemed to be so complete that friends of the Hawaiians turned annexationist in despair, hoping that the American government would protect Hawaiian interests better than the existing government seemed able to do.

The struggle was hard fought. Both Kamehameha IV and Kamehameha V, whose reigns covered the critical years from 1854 to 1872, were determined to reduce the influence of the Americans. The former gradually dispensed with his American ministers and encouraged the foundation of the 'Hawaiian Reformed Catholic Church'—a body with Anglican connexions—as a counterpoise to the 'Hawaiian Evangelical Association', which controlled the former American missionary churches. The latter abrogated the democratic constitution of 1852 and replaced it by one which greatly increased the personal power of the king. But the reforms had more of form than substance. The price of independence continued to be compromise with the settlers. When the planters required additional labour, the government obtained it for them—from China, Japan and the South Seas—but, when the king decided to build a hospital in the hope of reducing the alarming death rate among native Hawaiians, he had personally to raise the funds for the enterprise.

In 1872 the situation worsened. Kamehameha V died without naming a successor. The new king had, therefore, to be elected by parliament. The candidate whose policy found favour with the American settlers, William Lunalilo, was chosen. Little more than a year later he died. Another election became necessary. David Kalakaua, who on the previous occasion had outlined a pro-Hawaiian policy, profited from his mistake, courted foreign support, and was successful. Once in power he strove continuously to prevent the settlers gaining control of the state; but he was forced to make compromises, and his reign in effect prepared the way for the final overthrow of the kingdom in 1893, two years after his death. This was to be the final act in a drama which had begun when the 'Forty-Niners' were pouring into California. For nearly fifty years the Hawaiian kingdom had been slowly dying. Behind a facade of native rule the foreign residents had increasingly dictated policy.

The most remarkable example, however, of settler domination of a native government was provided by Fiji between 1871 and 1874.

In the former year the chief Thakombau (Fig. 94) assumed the title and powers of *Tui Viti* (' King of Fiji '). Behind him in this action, and largely responsible for it, was a group of merchants and planters, led by a retired naval officer. Their aims, apart from that of maintaining order in the islands, were entirely concerned with the welfare of the settler community; they wished to provide secure tenure of land, to undertake public works and establish communications, and

Fig. 94. Thakombau of Fiji

After a photograph taken in 1877, in the possession of the Museum of Archaeology and Ethnology, Cambridge.

to give increased confidence to overseas investors. A bi-cameral legislature was set up, in which the elective chamber was representative of the Europeans alone. The ministry, similarly, contained on Fijians. Government policy thus naturally favoured the settlers. The system of taxation, for example, proved more effective in forcing

Fijians to work for the planters than in raising revenue. But, while settlers were willing to receive such assistance, they very generally refused to admit the necessity for any restrictions on their treatment of their labourers and other natives, and in such matters they almost invariably protested against unfavourable decisions of the courts.

On several occasions the government was faced by active settler rebellion, and it was continually short of funds. Finally, an enquiry was sent to the British Foreign Office asking whether Britain was prepared to annex Fiji. Commissioners who were sent out decided in favour of annexation, and from the time when their opinion became known, early in 1874, the Fijian government became almost inoperative.

In territories such as Fiji and Hawaii, with a mixed population of Europeans and of less advanced peoples, European settlers believed that their own interests should always predominate when they conflicted with those of the remainder of the population. Justice could thus only be maintained by a government in some degree indifferent to their opinion. The governments of Hawaii and Fiji had shown that independent, nominally native, regimes were not strong enough to show such indifference ; nor, even at the cost of becoming instruments of settler policy, could they retain the loyalty of a white community. Annexation by a Western Power thus became desirable in the interests of the native inhabitants. Largely for this reason Britain and the United States were to be gradually forced to abandon their policies of avoiding fresh acquisitions of territory in the Pacific.

In other respects, too, circumstances had changed between 1840 and 1870 ; and the Powers were beginning to think less of the responsibilities of governing Pacific islands and more of the opportunities which their possession would bring. On the Pacific coasts of the United States, Australia and New Zealand cities had grown up where there had been only villages thirty years before ; Japan had been opened to trade; and the semi-seclusion of China was being steadily broken down. By 1870 the Pacific was already an important highway. Steamer services linked the principal ports round its borders. Island bases had become desirable as coaling stations. Thus, in 1867 France had acquired a protectorate over Rapa and the United States had annexed Midway islands. Henceforth, the usefulness of various islands as ports of call for mail steamers and as sites for naval bases was constantly under discussion. But of even greater immediate importance than such broad questions of strategy and

international trade were the more limited interests, economic, military and political, of the countries geographically closest to the islands.

The United States, alone among Powers interested in the Pacific, was willing at this time to acquire island territories; and her willingness was directly related to the contemporary development of her mainland regions facing the Pacific. The principal American gain at this time was the conclusion, in 1875, of a Reciprocity Treaty with Hawaii (virtually establishing free trade between the two countries). Both by its economic and its political clauses it brought annexation appreciably nearer.

The Australian colonies and New Zealand had a similar interest in the islands further south. Australian expansionist sentiment was made up of the usual ingredients. Colonial merchants possessed a large share of the trade of the islands; a majority of the settlers in Fiji and the New Hebrides, and many others elsewhere, had migrated from the colonies; and Australian communications, and even the security of the continent, might be endangered in time of war if hostile Powers were established in the Western Pacific. Those who looked into the future saw a steady increase in all of these interests. To many it seemed absurd to question Australia's future role in the Pacific. Of Fiji they wrote, 'These islands belong to Australia. They are, by their geographical position, the birthright of Australians'; and of New Guinea, 'Australian instinct points to the possession of this great island'. But the colonists lacked both the resources and the legal power to act by themselves. They could merely hope to impel the Imperial government into action by their petitions and by public agitation.

New Zealand is much nearer to many of the Pacific islands than is Australia. But for twenty years after the beginning of organized colonization (in 1840), New Zealand settlers were fully occupied with their internal problems. In the 'sixties, however, Auckland merchants and shipowners began to take an active part in the trade of the islands; and many New Zealanders had an interest in cotton plantations in Fiji. By 1870 men had begun to conceive of Auckland replacing Sydney as the premier centre of commerce with the south Pacific. It chanced that at this time the leading figure in the New Zealand government was Julius Vogel, 'the most audacious adventurer that perhaps has ever held power in a British colony' (as a high official in England described him). Vogel seized upon this vision; elaborated it into the proposal of a great Pacific Dominion,

embracing all the islands in the south Pacific not already in the possession of foreign Powers, with New Zealand as the metropolis; and adopted it as government policy. The new Dominion of Canada was his model. It seemed to him that his proposed Dominion was just as natural a political unit as was Canada. New Zealand itself was a country inhabited by two races—Europeans and Maori—so was Fiji, so was Samoa, and so would become many of the other groups to be annexed. New Zealand, he argued, was specially fitted by experience to undertake the government of native races. In New Zealand all this seemed obvious enough. Even the Governor agreed. The ministry sent home memorandum after memorandum urging acceptance of the proposal. But the Imperial government remained unimpressed. Active agitation ended when Vogel left New Zealand in 1876; but a heightened interest in the political future of the Pacific islands remained. Henceforth, New Zealand, like the Australian colonies, played an important part in the development of British policy in the Pacific.

The one grain of satisfaction obtained by the Imperialists of Australia and New Zealand was the decision of the British government to act upon the advice of its commissioners in Fiji. In October 1874 the group was annexed. This act had become necessary because of the breakdown in local government; but many subsidiary factors added to its desirability—the need for still more effective control of the labour trade, the suitability of the islands for tropical agriculture, and their position almost on the direct steamship routes between Australia and the United States. It was thus a fitting climax to an epoch, for it provided, within a limited area, a solution of most of the problems with which European governments had been concerned in the Pacific during the preceding 25 years.

THE EXTENSION OF WESTERN CONTROL, 1875-1914

Control in Independent Areas

Although British action in Fiji was thus a portent of the future—foreshadowing the eventual partition among the maritime Powers of all the independent islands of Oceania—it did not lead at once to annexations elsewhere. On the one hand, none of the interested Powers wished to precipitate a general scramble for Pacific islands; and, on the other, annexation led to expenses of administration which it still seemed possible to avoid.

Great Britain had decided, however, as has been mentioned, that British subjects in the independent islands should be brought under more effective control. Though this decision had been formed from consideration of the evils of the labour traffic, machinery was to be set up to deal with all forms of undesirable practices. For this purpose, the additional offices of High Commissioner and Consul-General for the Western Pacific were conferred upon the Governor of Fiji in 1877. The jurisdiction of the High Commissioner was to extend over all islands not under the control of Great Britain or any other Western Power; and a court was set up, with the Chief Justice of Fiji as its principal judicial officer, to try offenders.

At first the governments of several of the Australian colonies looked upon the High Commission with disfavour. They saw it as an unsatisfactory alternative to their own desired policy of widespread annexation. Queensland, in particular, resented the opposition of the first two High Commissioners to the annexation of eastern New Guinea, besides disliking the stern view which they took of offences by colonial labour traders. Many naval officers, too, were loth at first to accept directions from the High Commissioner upon matters in which responsibility had previously rested so largely with them. But once the system had become understood it worked with comparatively little friction.

As with the older punishment acts (p. 285), a major difficulty lay in apprehending those suspected of offences. Occasionally men who were wanted were rash enough to appear in Fiji or one of the Australian colonies, but more usually they had to be tracked down by ships of the navy. Evidence, too, was very often faulty or unreliable, and there was frequently difficulty in knowing what blame to attach to actions performed in the unusual circumstances existing in many of the islands. A case of the latter type which aroused great controversy was that involving the Rev. George Brown, a Methodist missionary in New Britain. Following the murder early in 1878 of a native minister and several native teachers by people in the interior of New Britain, Brown agreed to become one of the leaders of a punitive expedition. The expedition was successful and over a hundred of the tribe responsible for the murders were believed to have been killed. When news of this reached Australia and Fiji, a strong demand arose for Brown's trial on a charge of manslaughter. The vociferous applause of the labour traders seemed to many only to strengthen the case against him. On the other hand, he had the support of many responsible people, including the commander of a

German man-of-war which happened to be in New Britain not long after the occurrence. Eventually a summons was issued against Brown, but he was never brought to trial.

The work of the High Commissioner was, from the first, however, not confined to seizing and trying individual offenders against the law. It involved also building up through travel and regular reports a general picture of conditions in all the territories under his jurisdiction, so that any widespread disorders could be prevented or else checked as early as possible. The troubles to be expected differed widely from area to area. Round the coasts of New Guinea, where regular intercourse with Europeans was just beginning, and in most of Melanesia, there were frequent armed conflicts between natives and European sailors and traders, often with loss of life. To reduce the seriousness of these, the High Commissioner forbade the sale of firearms; but the effect of the regulation was limited, owing to the freedom still enjoyed by non-British traders. In New Guinea there was the additional duty of curbing the activities of ill-organized colonizing and gold-prospecting expeditions, and in the New Hebrides, after 1887, of co-operating with the Anglo-French Joint Naval Commission.

In the more advanced territories of Tonga and Samoa, and to some extent in the smaller Polynesian areas such as Niue, the work of the High Commissioner and Consul-General was of a quasi-diplomatic character. In both territories he was represented by a consul. In addition to their normal duty of representing British commercial interests, these officers usually acted as informal advisers of the native governments and tried to protect them against the schemings of European adventurers. This formed a large part also of the work of the High Commissioner himself on his periodical visits. In Tonga, from the establishment of the High Commission till 1890, a constant watch was kept on the activities of the Rev. Shirley Baker, a British subject who had become Premier of the kingdom. Successive High Commissioners visted Tonga, to urge the King and chiefs either to dismiss Baker or to reduce his powers and to repeal many of the oppressive laws which had been passed owing to his influence. In such ways it was hoped to teach the native rulers how to grapple with the problems of government brought about by European penetration. In this instance, however, such tuition proved insufficient. Baker had finally to be deported; and, at the request of the King and chiefs, a member of the administration service in Fiji was sent to Tonga to assume temporarily the office of Vice-Premier in order to

establish the government upon a more regular and more constitutional foundation.

Samoa, too, like all the native monarchies of the Pacific, had experienced the dominance of European adventurers. In July 1875 an American, Col. A. B. Steinberger, had accepted the office of Premier. Less fortunate than Baker and many others, he was seized and imprisoned on board a British man-of-war after only a few months' rule. His departure led to a prolonged period of unsettlement, lapsing at times into civil war. The native government, unstable and changing frequently in personnel, was able to offer little guarantee of protection to European interests. At Apia the settlers in 1879 formed a municipality, which framed laws, raised taxes, and established a court; and this for a time maintained fairly orderly conditions within the area which it controlled. But it was only a local and temporary improvement. The action of the three interested Powers—Germany, Great Britain and the United States—in negotiating treaties between 1876 and 1879 by which they each gained the right to a naval station in the islands, freed their subjects from the obligation to pay customs duties, and gained a wide variety of other privileges, made it finally impossible, within the existing framework, to establish a strong native government. The periodical visits of the British High Commissioner, even when he gained the support of the German and American consuls, could produce only superficial improvements.

In 1885 and again in 1886 representatives of the Powers visited Samoa to study the situation. J. B. Thurston, who was the British representative on both occasions, argued that a native government could be made effective, provided a few Europeans were added to it and provided the commanders of warships in the islands were prepared to lend it the sanction of their guns. But a conference of the three Powers held in Washington in June and July 1887 completely failed to reach agreement as to the action to be taken. A few weeks later petty disputes in the islands led to a declaration of war by Germany on the government of King Malietoa. As a result, Malietoa was exiled by the Germans and replaced by the chief Tamasese. For a time the new government, aided by a German, Captain Brandeis, maintained order, but in September 1888 a formidable revolt broke out. Only the intervention of German warships prevented its early success. They, in their turn, were continually shadowed by British and American warships, for it seemed clear to their commanders that the Germans were attempting to gain com-

plete dominance. Relations remained tense until the catastrophic hurricane of March 1889, when three German and three American warships were driven ashore.

This vigorous German naval intervention led to another conference of the Powers in Berlin between April and June 1889. By its final act it reinstated Malietoa and declared Samoa to be an independent and neutral state. Independence was, however, to be more nominal than real, for the Powers were to possess the right to nominate a number of the most important government officials. The Chief Justice, who was to be so appointed, was to possess, in addition to ordinary civil and criminal powers, jurisdiction in matters relating to the election of a king, to the powers which the king should enjoy, and in disputes between the Samoan government and the Powers, and many other matters. The president of the municipal council of Apia, who was to be similarly appointed, was to hold the additional position of chief adviser to the King. All ordinances of the municipal council had to be approved by the consuls, and they, like the naval officers stationed in Samoan waters, had considerable general prestige. Finally, there was to be a land commission to examine claims and titles to land. Thus, in the words of Henry C. Ide, who served for a time as Chief Justice, 'instead of one king there were six'. With so many authorities it was almost impossible to place responsibility; and no constructive proposal could be carried out till the agreement of several often mutually antagonistic groups had been obtained.

The setting up of the condominium in Samoa was almost the last attempt by the maritime Powers to avoid more direct intervention. Its failure persuaded them, at least for a time, that there was no satisfactory alternative—wherever in the Pacific European interests were well developed—to the assumption of final political responsibility by a single Western Power.

Annexation by the Powers

The acceptance of annexation as the solution in Samoa was so long delayed because of the difficulty of reconciling British, German and American interests. The first area in regard to which annexation became a matter for widespread discussion after 1875 was New Guinea.

Until well past the middle of the nineteenth century almost the only Europeans to have seen the shores of New Guinea were the companies of exploring or surveying vessels. Between 1865 and 1870, however, settlements were formed on a number of the islands

of Torres strait as centres for *bêche-de-mer* fishing; in 1871 mission work began, with the stationing of native teachers of the London Missionary Society on various islands off the coast; and about the same time European traders began to visit the mainland coast. During the 'seventies, also, mail steamers from Australia to India began to pass regularly through Torres strait. Potentially of even greater political importance were the various projects from 1867 onwards for settlement or prospecting in New Guinea. In particular, in 1878 there was a rush of gold miners to Port Moresby, which led the Queensland government to send an agent who maintained order among the miners.

These mining and colonizing projects achieved no success; but the less spectacular trading development continued. Interest in it was not confined to Australia, for the German companies which were already working in the Bismarck archipelago were beginning to extend their operations to the north coast of the New Guinea mainland. In Australia this advance was feared. It was held not only that New Guinea was a natural dependency of the continent, economically and politically, but that it would be disastrous, strategically, for it to come under the control of Germany or any other foreign Power. By the beginning of 1883 the government of Queensland had become so anxious that the Premier cabled to London for permission to annex the island. When no immediate reply was received it was decided to act without authority. An agent was sent to New Guinea to 'take possession in the name of Her Majesty of so much of the island as is not in possession of the Netherlands Government'; and on 4 April the British flag was raised at Port Moresby. In itself this unauthorized act was quite without legal effect, but it was felt that, faced with such strong feelings in official circles in the Australian colonies, the British government was likely to confirm it.

In fact, the reply of the Colonial Secretary contained two important proposals—that the colonies should federate, if they wished to exercise a greater influence in the Pacific; and that a protectorate should be declared over 'the coast tribes', if the colonies would provide funds for its administration. To discuss these proposals, an Inter-Colonial Convention, attended by representatives of all the Australian colonies and of New Zealand, and by the Governor of Fiji, met at Sydney later in the year. The convention considered the question of annexation in the Pacific in its broadest aspect and declared that any acquisition of territory south of the equator by a foreign Power was undesirable. On the narrower question of New Guinea, it urged

that steps be taken immediately to acquire the whole of the non-Dutch portion of the island.

In the middle of 1884, while the plan for a British protectorate was still being considered, the German government declared its desire to protect German interests in the area. No agreement as to a delimitation of spheres of influence was reached; but in the latter months of the year and the beginning of 1885 both British and German representatives were active in the region—the British in the south-east and the Louisiade archipelago and other islands to the east of the mainland; the Germans on the north coast between the Huon gulf and the Dutch boundary and in the Bismarck archipelago. Protests were made on both sides at the extent of the claims; but an agreement was reached in June, and after that time the status of New Guinea ceased to be a matter for international discussion.

The German annexations in the New Guinea area formed part of a broad programme of colonial expansion. In the Pacific they were followed, later in 1885, by the raising of the German flag on Choiseul in the northern Solomons; by the negotiation of a treaty with the chiefs of the Marshall islands, establishing a protectorate; and by the raising of the German flag on Yap, in the Carolines. The last action led, as had been anticipated, to an immediate protest by Spain. The matter was finally referred to the Pope for arbitration. In regard to sovereignty, he decided in favour of Spain; but Germany was accorded complete freedom to trade, and this prepared the way for the later purchase of the islands. In the following year an agreement was reached with Great Britain defining the respective spheres of influence of the two Powers in the Western Pacific. A line was drawn from western New Guinea to the north-east of the Marshall islands (Fig. 95). Germany was to be free to acquire sovereignty and to accept protectorates north and west of this; and Britain was to enjoy similar rights south and east of it, except in Tonga, Samoa and Niue, which were to remain neutral regions.

France also was consolidating her Pacific interests. In 1880, three years after the death of Queen Pomare, who had granted the French a protectorate in 1842, Tahiti and its dependencies (including the Tuamotu archipelago and some of the Austral islands) were annexed. Rapa, the remainder of the Austral islands, and the Mangareva group, were annexed in immediately following years. In 1887 a protectorate was declared over Uvea (Wallis) and Futuna, in the Western Pacific. Finally, in 1888, Britain signed an abrogation of the declaration of 1847 in which France had agreed not to take

possession of the Leeward group of the Society islands, thus making possible the final rounding out of French interests in the Eastern Pacific.

This last act had arisen out of Anglo-French discussions regarding the New Hebrides. In certain French circles, particularly in the adjacent colony of New Caledonia, there was a strong demand for annexation of the group, and it was even claimed that it had been included by implication, as a dependency, in the proclamation of sovereignty over New Caledonia in 1853. In 1882 a company was formed at Noumea to colonize the islands, and there were other signs—notably an agreement with Germany in 1885 by which the latter Power undertook not to oppose French annexation—that action was in contemplation. In Australia this was strongly opposed. Both economic and missionary interests in the New Hebrides at this time were largely British; and there was the further feeling, as with New Guinea, that the occupation of the group by a foreign Power was a potential threat to the communications of the colonies. The protests were given a particular bitterness, however, owing to the proposals in France at the time for the expansion of penal colonization. The Australian governments had records of the arrival of several hundred escaped and time-expired convicts from New Caledonia, and they feared that they were about to experience an increase in this evil. A settlement of the New Hebrides problem was finally precipitated by the independent action of the government of New Caledonia in 1886 of sending troops to the islands to protect French settlers against attacks by natives. The French government declared its willingness to withdraw them when satisfactory arrangements had been made for the maintenance of order. As a result, a convention was signed in the following year by the two Powers providing for the setting up of a Joint Naval Commission of British and French officers for this purpose. As in Samoa, the potential conflict of interest of the two Powers led to a careful avoidance of the issue of sovereignty.

By 1890 a high proportion of the islands of the Pacific had thus either been acquired by one or other of the maritime Powers or become unavailable through the overlapping claims of several Powers. This served to increase the interest taken in islands still open to acquisition, which might be useful as coaling stations, as trading centres, or as fields for agriculture. Beyond this, the increasing penetration of all the inhabited islands by European traders and missionaries, and the consequent disruption of native political

systems, was making European administration the only bulwark against disorder. Thus Britain declared a protectorate over the Tokelau group in 1889, over the Cook islands between 1888 and 1892, over part of the southern Solomons in 1893 and over the remainder in 1898-9, over the Gilbert islands and the Ellice islands in 1896-7, and over Ocean island in 1900.

During the same years the slow process of American penetration of the Hawaiian islands was approaching its culmination. In 1890 the United States abolished all duties on imported sugar. The American domestic producer was, in future, to be assisted by bounties. By this act Hawaii lost its principal gain from the hardly won Reciprocity Treaty of 1875. The pecuniary loss to the sugar interests was estimated at between two and three million pounds a year. The only possible form of relief seemed to be annexation to the United States. At the same time there were subsidiary reasons for a revival of annexationist agitation. In 1887 the European residents had won from King Kalakaua a constitution by which political power passed largely into their own hands. In 1891 Kalakaua died and was succeeded by his sister Liliuokalani, who began at once to build up, often by rather dubious means, a party pledged to the restoration of royal power. In January 1893, Liliuokalani prepared to stage a *coup d'état* reforming the constitution. The annexationists were prepared for the opportunity with which they were thus presented. They declared the throne vacant and, under the protection of American marines, established a provisional government. At this point, however, their plan miscarried, for in the United States the Republican administration of President Harrison was replaced by a Democratic administration before the Senate had approved of the annexation treaty. President Cleveland declined to support annexation. In July 1894, therefore, the government of Hawaii declared the state an independent republic, and waited for the Republicans to return to power. This came about in 1897, following the election of McKinley to the presidency. In April 1898 war broke out with Spain, and Hawaii gained increased importance in American eyes as a potential naval base. A few months later the islands were annexed.

The final years of the century saw the settlement of most of the other territorial questions which remained, and the final passing of the era of independent Polynesian states. By the treaty which brought the Spanish-American war to a close in December 1898, the United States obtained (in addition to its gains elsewhere) the island

of Guam, in the Marianas. And the German government, seizing the opportunity of Spain's embarrassment, purchased from her the remainder of the Marianas and the Caroline islands. Another series of settlements arose from the reconsideration of the situation in Samoa.

By 1898 the condominium administration in Samoa stood condemned by the judgment of all who had studied it at first hand. The death in August of that year of King Malietoa Laupepa provided a natural opportunity for discussing possible changes. The German government, therefore, proposed the allocation of Tutuila, which contained the important harbour of Pango Pango, together with the Manu'a group to the United States, while Germany herself took the two larger islands of Upolu and Savai'i and their off-lying islets. In return for renouncing her claims, Britain would be compensated elsewhere in the Pacific. The withdrawal of Britain, it was recognized, would be strongly opposed by the governments of New Zealand and Australia; but British entanglements in other parts of the world—notably the repercussions of the 'Fashoda incident' in the Sudan and the rapidly deteriorating situation in South Africa—made it a good time, from the German point of view, for raising the proposal.

Before discussion was well under way civil war had broken out in Samoa. Commissioners were sent to the islands by the three Powers. Their reports emphasized the need for immediate assumption of control. Discussion continued more energetically, and on 2 December 1899 a tripartite convention was signed on the lines of the original German proposals. Compensation by Germany to Britain took the form of the renunciation of German rights in Tonga, the cession of the German islands in the Solomons to the south of Bougainville, and various concessions in Africa.

In Tonga, the King and the leading chiefs took great pride in their independence; but, in practice, they had been since the establishment of the Western Pacific High Commission under the informal suzerainty of Great Britain. Now, in 1900, the British Government decided to seek Tongan acceptance of a formal protectorate. On 18 May a treaty was signed. A few weeks before, a somewhat similar treaty had been signed with the chiefs of the isolated island of Niue, some 240 miles to the east of Vava'u in Tonga.

By the end of 1900 the one question of sovereignty remaining unsettled was that of the New Hebrides. The Joint Naval Commission had long since been accepted as quite insufficient for the main-

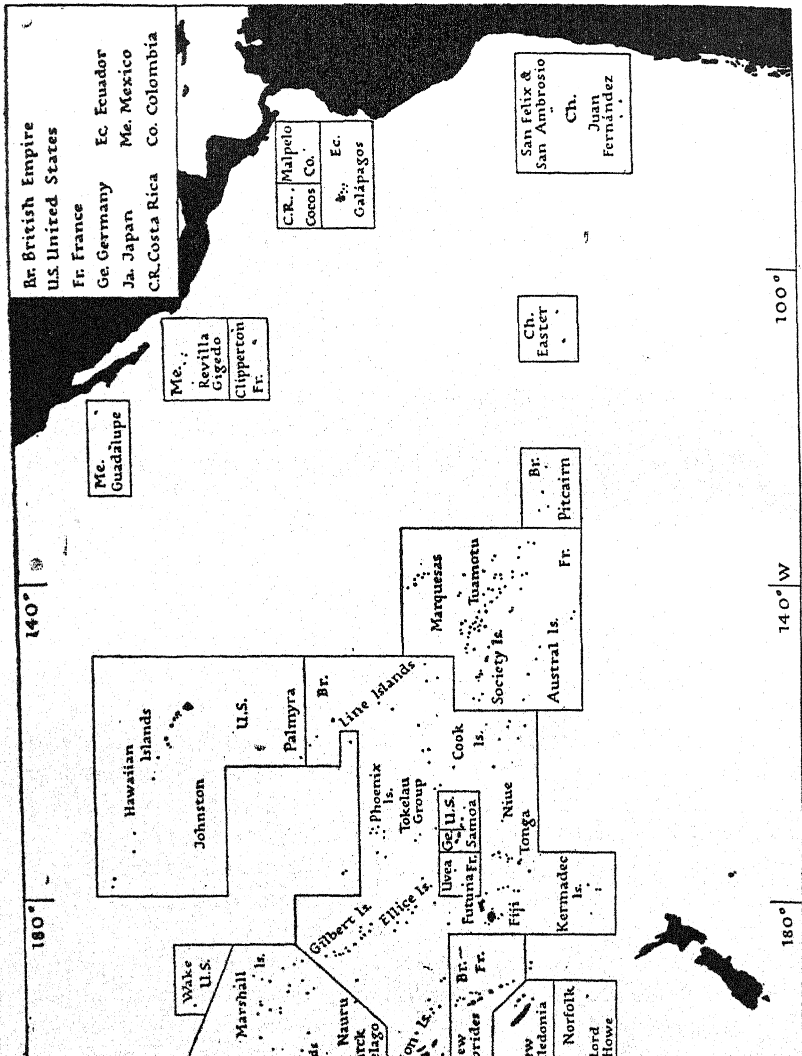

Fig. 95. Sovereignty and political control iu the Pacific area in 1914.

tenance of order. In 1902 Britain appointed a Deputy Commissioner to the group, and France made a similar appointment shortly afterwards. At the same time discussions regarding a permanent settlement had already begun. Feeling in New Caledonia and in Australia and New Zealand still made it difficult for either government to consider withdrawing entirely, while neither was willing to jeopardize the more important discussions which were proceeding at the same time on the recognition of the special interest of Britain in Egypt and that of France in Morocco. Thus deliberations were ended in 1906 by the decision to establish an Anglo-French condominium. In the ensuing years the new administration which was set up was criticized in the same words which had been applied to the condominium administration in Samoa in the 'nineties.

Economic Development

The period of annexation had also been one of great economic advance. In Hawaii the Reciprocity Treaty of 1875 had led to a considerable influx of capital, mainly from America. Many sugar mills were built, and much new land was brought into use for sugar cultivation by means of irrigation. The quantity of sugar exported from the islands rose from about 11,000 tons in 1875 to over 110,000 tons in 1890. The total value of all exports increased from about £450,000 in 1870, to over £2,600,000 in 1890, and to about £7,250,000 in 1905. In Fiji the growth was less steady. The failure of cotton after 1873 led to temporary dependence mainly on copra and then, from about 1880, to large-scale cultivation of sugar. Lacking an assured market, such as the Hawaiian planters possessed in the United States, the Fijian sugar industry passed through a period of great difficulty. Eventually, however, conditions improved, and the value of the sugar export rose from about £209,000 in 1895 to about £540,000 in 1905. Copra, which remained the second most important source of income, similarly showed a big

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Fig. 95. Sovereignty and political control in the Pacific area in 1914

The lines have been drawn to separate the various island groups. They do not generally indicate the precise limits of sovereignty or of spheres of political influence. An exception is the line enclosing the German possessions; between New Guinea and the north of the Marshall islands this indicates the dividing line between German and British spheres of influence, as laid down in the Anglo-German agreement of 1886 and modified in the further agreement of 1899. Based on: (1) G. H. Scholefield, *The Pacific, Its Past and Future . . ., end map* (London, 1919); (2) National Geographic Society 1 : 35 M Map of the Pacific Ocean, 1936; (3) other sources.

increase. In New Caledonia the production of nickel, which began in 1875, was undertaken on a large scale after 1889. Together with the development of other less important mining enterprises and with the growth of agriculture, this pushed up the value of exports from about 300,000 francs in 1870 to over seven million francs in 1890 and to over fifteen million francs in 1913. In 1899 the discovery that the hitherto unimportant islands of Nauru and Ocean contained immense quantities of phosphate brought into existence a new enterprise of great value; and between 1908 and 1913 over one and a half million tons of phosphate were exported from the two islands—perhaps rather more than three-quarters of the total production of the central equatorial islands between 1858 and the end of the century. In the less developed groups, such as the Gilbert islands, the Ellice islands, the Solomons and the New Hebrides, the production of copra by the native peoples was on an increasing scale; and, especially in the Solomons and the New Hebrides, lands were taken after about 1900 by Europeans for coconut plantations.

During the same period there was great development of both trans-Pacific and local shipping services. In 1869 the Union Pacific railway, linking San Francisco with the eastern parts of the United States, had been completed, and in the following year a steamer service from San Francisco to Sydney, *via* Honolulu and Auckland, was begun. In 1875 this service was reorganized and better ships were employed. Two years earlier a company had been formed to operate a line between Sydney and Hong Kong. The completion of the Canadian Pacific railway in 1887 led to the starting of two further trans-Pacific services—from Vancouver to Hong Kong, in 1887, and, in 1893, from Vancouver to Sydney, with Suva and Wellington added later as additional ports of call.

At the same time local steamer services to the islands were being established. Before 1890 there were various British-owned lines linking Australia and New Zealand with Fiji, Tonga, Samoa, the Society islands, and other island groups of the south Pacific. The French Compagnie des Messageries Maritimes maintained services from Sydney to New Caledonia and other French Pacific possessions. And there were also German services from Australia to the German Pacific territories and other groups.

Thus well before 1914 the economic, as well as the political, position in the Pacific islands had taken on the form which, in broad outline, it retained until the outbreak of war in 1939.

THE MODERN PACIFIC, 1914-39

On the outbreak of war in 1914 Australian forces occupied German New Guinea, the Bismarck archipelago, and the German Solomons; New Zealand forces occupied Western Samoa; and Japanese forces occupied the German possessions in Micronesia. Though primarily dictated by military necessity, this action represented for Australia and New Zealand an occupation of territories which their political leaders had never ceased to think should always have been theirs; for Japan it represented the beginning of a period of southward expansion which is only now (1944) coming to an end. At the end of the war, the two Dominions and Japan were given mandates for the administration, under the supervision of the League of Nations, of the territories which they had occupied. Elsewhere, there were no changes; and, with a few minor exceptions (vol. II, pp. 473, 508, 518), sovereignty and political control in the Pacific remained unchanged till the outbreak of war between Japan and the other Pacific Powers in 1941.

Recent changes in the social and economic conditions in the islands are discussed elsewhere (Chapters XII, XIV). Strategically, their position has been revolutionized by the development of air communications and by the growing industrialization of the countries bordering the Pacific basin. Islands such as Oahu, Palau, Guam, Truk, Borabora, and Espiritu Santo, lying on the fringe of the island region and possessing good harbours, have gained a new importance as naval bases for the defence of the coasts and trade routes of the Pacific nations, or for offensive action against them. Remote atolls such as Midway and Canton, which had for long periods remained uninhabited, have become important as fuelling bases and meteorological stations for trans-Pacific air services. Attention has been turned to the more careful definition of sovereignty over some islands; and the whole question of the value of Pacific islands for communications has begun to be re-examined. Thus, as the economic and political development of the populous countries which fringe the Pacific has made more obvious the relatively insignificant contribution which the islands can make to world resources, it has given them a new importance as a strategic frontier of America, of Asia, and of Australasia.

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Chapter XI

POPULATION

Distribution and Density : Composition by Race and Nationality : Composition by Sex and Age : Trends of Native Population : Causes of Decline and Increase of Native Population : Trends of Immigrant Population : Trends of Mixed-blood Population : Bibliographical Note

The Pacific islands, though scattered over a vast oceanic area, carry a very small proportion of the world's population. The total figure cannot be accurately ascertained, for several reasons. In some areas, notably in the interior of much of New Guinea, administrative control has not been fully established and a complete count of the population is not possible. In some other areas the census machinery is still imperfectly organized; because the people frequently move from one island to another, or the island is very isolated, or there is little official interest in exact returns, no precise recent record is obtainable. For the islands administered by the Japanese before the war, a further difficulty occurs: the official population statistics, though indicative of the general position, are not necessarily reliable in detail and it is possible that some population changes have been concealed deliberately in the most recent figures (those of 1938 and 1939). But on the basis of available census material, supplemented by official estimates, it would seem that the total population of the Pacific islands, about 1940, was a little more than 2½ million. This is roughly equivalent in size to the population of one of the smaller European countries; it is about the same as that of Lithuania, rather less than that of Norway or of Eire, and about two-thirds of that of Denmark. It is only about one-twentieth of the population of Great Britain, which has less than one-quarter of the land area.

Distribution and Density

As Fig. 96 shows, by far the greater number of the Pacific islands people live in the western part of the area, particularly on the New Guinea mainland, which alone contains over a million inhabitants. The island of New Britain, in the Bismarck archipelago, has more than 100,000 inhabitants; the Solomon islands, including Bougainville and Buka, have nearly 150,000; Fiji, according to the official estimate of 1941, has about 225,000. In the Eastern Pacific, on the other hand, with the exception of the Hawaiian islands, which have

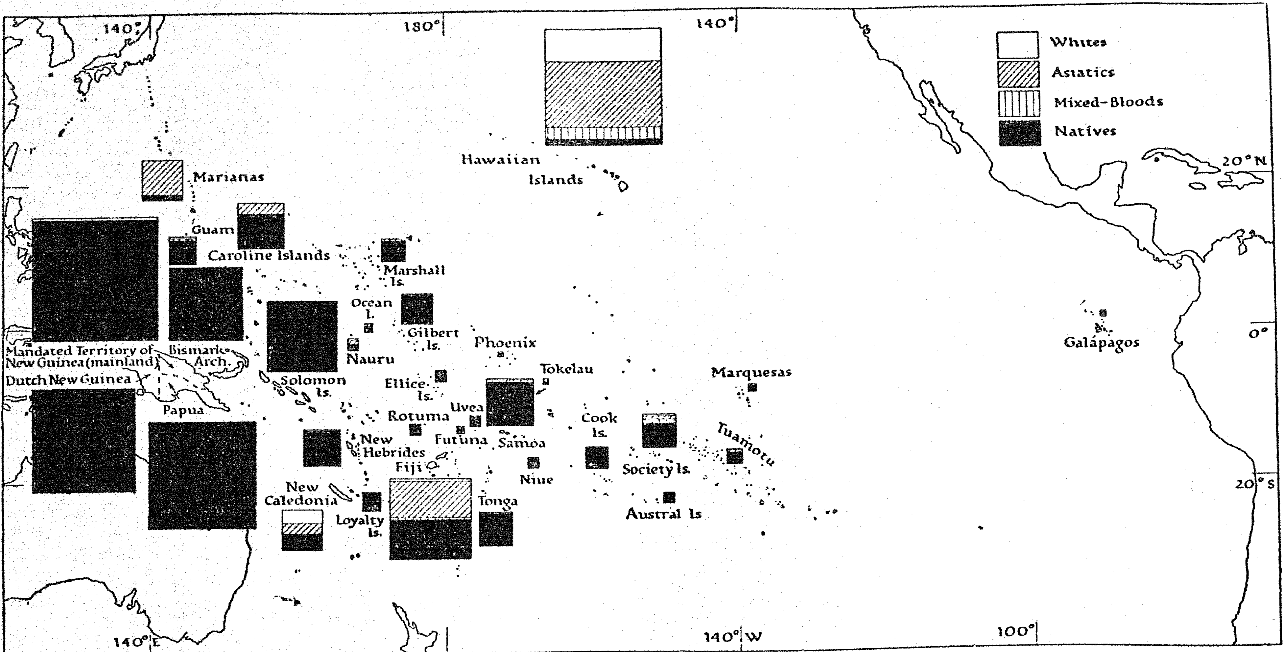

Fig. 96. General distribution of population in the Pacific islands, about 1939

The islands have been grouped on a geographical basis rather than on a political basis; the total population of each area named is proportional to the size of the square. The smallest square represents 1,000 people; the largest, 450,000. (Populations of less than 1,000 are omitted. Small proportions of mixed-bloods, Europeans and Asiatics are not shown.) Based on various sources.

a total population of over 400,000, there is no island group with a population approaching 100,000.

To illustrate the distribution of population of such a huge area either diagrammatically or in tabular form, it is necessary to use comparatively large administrative or geographical units. But this tends to conceal an essential feature of most Pacific island populations —that they are not concentrated in large masses of an urban or semi-urban type, but are in fact distributed fairly thinly as small rural units in villages or other settlements over a great number of scattered islands. What distinguishes these units from comparable ones in (say) a European countryside, is that their inhabitants, so far as any single island is concerned, and often even in small regions of a large island, form separate communities differing considerably from their neighbours in culture, and frequently in language as well.

Examples of such small islands with autonomous or semi-autonomous populations are: Pitcairn, with 199 inhabitants (in 1934); Lord Howe, with 165 (in 1936); Norfolk, with 798 (in 1942); Easter island, with 577 (in 1942); the three Tokelau islands, with 1,170; Rotuma, with 2,740; Niue, with 4,104; Uvea, with 4,272; Futuna, with about 1,800—all in 1936. A large number of other islands, especially in the central Pacific, also fall in the same category. The Gilbert islands and Ellice islands had in 1936 a total population of more than 30,000. But this was distributed among 16 islands in the Gilbert group and 9 islands in the Ellice group. In the former there were 4 islands with populations of less than 1,000; 7 islands with populations of between 1,000 and 2,000; 4 islands with populations of between 2,000 and 3,000; and only one island with a population of more than 3,000. In the Ellice group no island had a population of more than 1,000, and only 4 islands had populations of more than 500. The Tonga group, with a total population of about 34,000 (in 1939), has two large and populous islands—Tongatapu, with a population of about 15,000, and 'Uta Vava'u, with a population of about 6,000—but the remainder of the group consists of small islands with populations for the most part of only a few hundred each.

Urban concentrations in the Pacific region are correspondingly few. The largest town is Honolulu, a modern city with a population of 181,000 in 1940. All the other towns of any size have populations of only 20,000 or less. Among the most important are: Hilo (Hawaii), with a population of about 20,000; Suva (Fiji), with about 15,000; Noumea (New Caledonia), Agaña (Guam) and

Garapan (Saipan), all with about 10,000; and Papeete (Society islands) and Koror (Palau), with rather less than 10,000. There were also many smaller townships, such as Lautoka (Fiji) and Rabaul (New Britan), with populations of from about 1,500 to 3,000.

For the Pacific area as a whole, taking only the total land area into consideration, the average density of population is extremely low. As nearly as can be estimated, the superficial area of the various islands, including New Guinea, is rather less than 400,000 sq. miles, giving an approximate average density of population of a little more than six persons per sq. mile. This is about the same as that in another large tropical region, French Equatorial Africa and the French Cameroons, which, however, cover a much greater superficial land area. Comparison with countries round the Pacific shows that while the population density of Australia is less than half that in the Pacific islands, that of New Zealand is 2½ times as great, that of the Philippines is 20 times as great, and that of Japan is nearly 80 times as great. Comparison with Old World countries of approximately the same land area as that of the Pacific islands shows that Egypt has a population density about seven times as great, and France and Germany together have a density more than 40 times as great. (Great Britain, with less than a quarter of the land area, has a density about 80 times as great.)

Although the average density of population is so low in the Pacific area, this is largely due to the comparatively thin peopling of a few large land masses, especially New Guinea. This main island, with more than four-fifths of the total land area of the Pacific and carrying nearly half the total population, has an average density of approximately 3·4 persons per sq. mile. If this be excluded, the average density of the other islands rises to 19 persons per sq. mile. But the range of population density is very considerable, even for the main island groups. It varies from less than 1 per sq. mile in the Galápagos to 5 per sq. mile in New Caledonia, 8 in the New Hebrides and in the Solomon islands, about 30 in Fiji and in the French Establishments in Oceania, 58 in Samoa, 72 in Hawaii, 125 in Tonga, 150 in the Japanese mandated islands and nearly 200 in the Gilbert and Ellice islands. However, more than 55% of the population is found in areas with a density of less than 10 persons per sq. mile, about 35% in areas with densities between 10 and 100, and less than 10% in areas with densities of over 100 (Fig. 97). As a rule, apart from the few towns, population is most dense in the comparatively small islands and atolls of the central Pacific. On Nauru and on

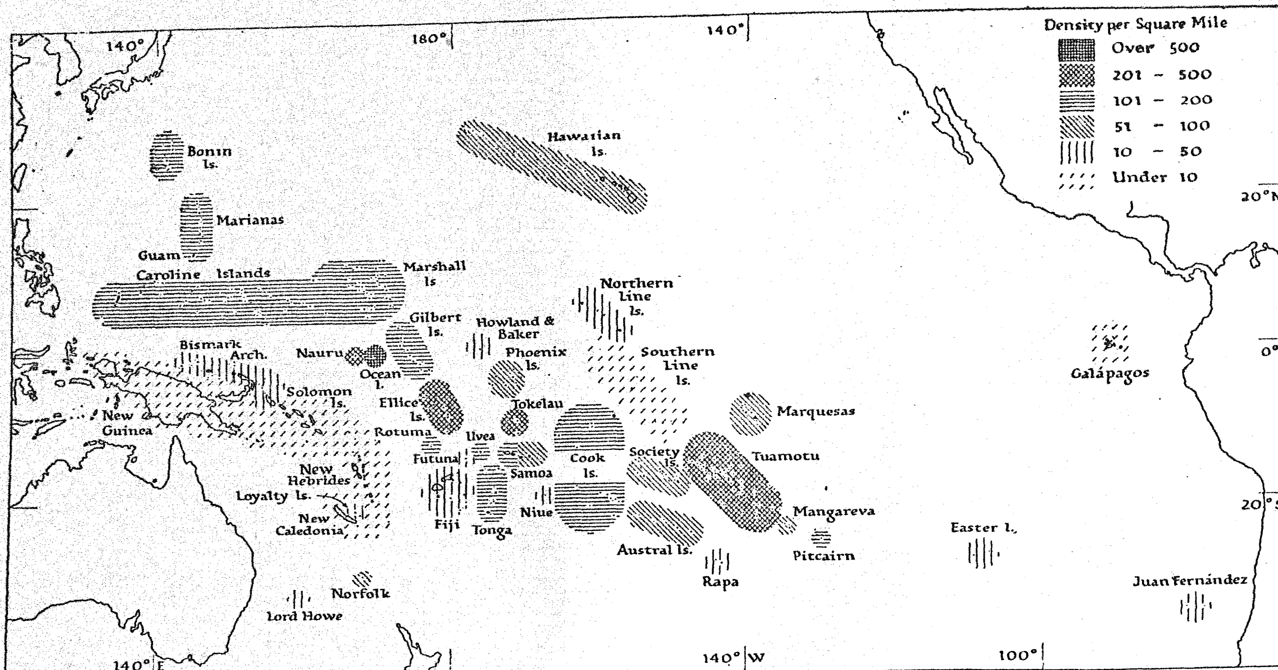

Fig. 97. Average density of population on island groups of the Pacific, about 1939

The areas covered by groups have been conventionalized and the positions of islands shown only approximately. Population density within a group often varies widely from island to island and from district to district. Based on various sources.

Ocean island, where phosphate is extracted, the concentration of labourers brings the respective densities to approximately 400 and 1,000 persons per sq. mile. But even in purely agricultural islands, such as some of the Gilbert and Ellice groups, or the isolated island of Tikopia in the Solomons, density reaches a figure of several hundred persons per sq. mile. The tendency to increase shown by some of these populations in recent times has created social and economic problems which, in the case of some of the Gilbert islanders, have been partly met by planned emigration to the Phoenix islands (vol. II, pp. 471–2).

Composition by Race and Nationality

In ethnic composition the population of the Pacific islands is heterogenous, and the proportions of the various elements show considerable variation in the different island groups.

The most important element, as far as political and economic power goes, is furnished by the 'whites', mainly people from Europe, or people from North America, Australia and New Zealand, whose immediate ancestors were European. But though their influence is so great, their numbers are comparatively small. In all they comprise a little less than 150,000, or about 6% of the total Pacific islands' population. Nowhere, except on the small islands of Norfolk and Lord Howe, are they numerically dominant. In the Hawaiian islands they constitute about one-quarter of the total population, and in New Caledonia a little more than one-third; but elsewhere they are only a tiny fraction of the total.

Numerically more important are the Asiatics, either immigrants or the descendants of immigrants. They comprised in 1940 about 430,000 in all, or between one-sixth and one-fifth of the total population of the islands. Their economic importance is considerable, mainly as a labour force but also in commerce; and in recent years they have tended to emerge as a factor in local politics—quite apart from the political aspects of the Japanese attempts at mastery of the Pacific. The greatest concentration of Asiatics is in the Hawaiian islands, where in 1940 they numbered about 250,000 (if the 52,000 Filipinos be included in this category). But a large number of these people were born in Hawaii. Japanese and those of Japanese origin comprised about 64% of the total Asiatics, Filipinos about 21%, Chinese about 12% and Korean about 3%. A large number of Japanese also occupied the Caroline islands and Marianas, numbering over 70,000 there in 1939; in the Marianas they outnumbered

the native population by ten to one. Elsewhere in the Pacific the numbers of Japanese were small. The Chinese in the Pacific, apart from the Hawaiian islands, numbered in 1940 about 13,000, with about 4,500 in the French Establishments in Oceania and the remainder scattered through most of the main groups. There were also about 6,000 Indo-Chinese and nearly 10,000 Javanese, mainly in New Caledonia and the New Hebrides, under French jurisdiction. In Fiji there is a large concentration of Indians, many having been born in the colony. In 1940 they numbered about 98,000, i.e., nearly as many as the native Fijians.

In all the major island groups except the Hawaiian islands, Fiji, the Marianas and the mainland of New Caledonia, the bulk of the population is still 'native'—Polynesian in the east, Melanesian and Papuan in the west, and Micronesian in the north-west (pp. 363-9). The Polynesians, numbering about 200,000 (excluding the Maori of New Zealand, who are not discussed in this Handbook), form about 10% of the total native population; the Melanesians and Papuans (difficult to separate statistically), number about 1½ million and form about 85% of the total; and the Micronesians number about 100,000 and form about 5% of the total. This predominance of native population in the Western Pacific is marked especially by the large numbers of Melanesians and Papuans in New Guinea, on the northern frontier of Australia. In most of the islands the natives provide a large proportion of the labour force needed for the plantations which are the basis for much of the white economy. As a whole they are peasant agriculturalists and fishermen, their standard of living is low, and they occupy a subordinate economic and political position.

An element of growing importance in the Pacific islands population, especially in the present century, is that of the mixed-bloods—often referred to as 'half-castes', a term which is of sociological rather than biological significance. The term mixed-blood can be used only in a relative sense, since none of the 'native' peoples of the Pacific themselves represent a pure racial type. Even before Europeans had become established in the region a great deal of intermixture of peoples had clearly taken place, both before the ancestors of the present inhabitants had come into the Pacific and in the course of their movements from one island group to another. But in modern times the ethnic mixture has become particularly significant because it has involved important questions of social adaptation—of the part to be played in the general community life

by the people of mixed blood, with parents often coming from cultures of widely different kinds and on levels initially far apart. Demographically, the mixed-blood element is often difficult to separate from other elements of a Pacific islands population, partly since these people themselves frequently prefer to be classed with one or other of the parent groups, and partly since some administrations make no specific category for them in the census records. In Polynesia, for instance, where privileges of land ownership and of rank may be associated with membership of the native society, many people of mixed blood tend to identify themselves completely or almost so with the Polynesian group, though genealogically their mixed descent can be traced. Again, for various reasons such people often feel that their strongest emotional ties are with the native group, which is usually that of the mother. On the other hand, a few administrations, notably the French, lay more emphasis on political status and social relationships than on ethnic distinction, and class people of mixed blood who live in European style as 'Europeans', or disregard a 'racial' classification in favour of one by citizenship. Thus a large number of persons in the French Establishments in Oceania are classed as 'French' who in fact are by origin partly European French and partly Polynesian. The total number of people of mixed blood either recognized officially or inferred from census material was about 60,000 in 1940. They comprised, in the main island groups, the following: about 500 in Tonga (about one to every 65 native Tongans); about 1,300 in American Samoa (about one to every 9 Samoans); about 3,000 in Western Samoa (about one to every 20 Samoans); about 5,000 in Fiji (about one to every 20 Fijians); about 5,000 also in French Oceania (one to every 6 or 7 Polynesians); and about 43,000 in the Hawaiian islands (outnumbering the native Hawaiians by two to one). But in addition there is a large number of people, possibly another 100,000, with some admixture of European or Asiatic blood, often three or four generations back.

The exact composition of the Pacific islands' population in terms of political status cannot be determined, because of the lack of full data. Broadly speaking, as far as administrative control was concerned, in 1940 the position was as follows (taking the various forms of colonies and territories, including mandates, together). By far the largest section of the population, about $1\frac{1}{2}$ million, is under British control, mainly in the Western Pacific; the United Kingdom administers about 360,000 people, Australia rather more than

1 million, and New Zealand about 76,000. The United States controls a population of about 460,000, mainly in Hawaii. The Dutch control a population of some 300,000, in the west of New Guinea; the Japanese some 120,000, in the north-west of the Pacific; the French some 100,000, fairly equally distributed between the east and the west of the Pacific. In addition, the British and the French governments together control about 43,000 people in the New Hebrides, and the British and the United States governments a very small population—well under 1,000—in Canton and Enderbury, a condominium. Other administrations in the Eastern Pacific control small populations, totalling about 2,000.

By no means all of these people enjoy full political privileges from the countries in whose charge they are. A large number are American citizens, French citizens or British subjects, as the case may be—either by right of birth or by other process such as naturalization. But there are many exceptions. In French Oceania, for instance, there were in 1931 about 22,000 French citizens, of whom about 17,000 were native Polynesians. The remaining Polynesians in the Establishments were subjects of France, with more restricted rights, a condition arising from the particular circumstances in which French control of the various island groups was acquired. Chinese born in the colony could formerly obtain French citizenship by simple declaration, but in recent years they have had to proceed to it by the more complex process of naturalization. Both in the French Establishments in Oceania and in New Caledonia provision is made whereby natives who are French subjects may obtain citizenship if they have fulfilled certain conditions, of which one is normally a period of state service. In the United States sphere, all persons born in the Hawaiian islands automatically acquire American citizenship. While a large number of Asiatics in the territory hold this status—by 1930, 72% of the Chinese and 58% of the Japanese were locally born—there is still a considerable proportion whose political affiliations are legally with their country of origin. Moreover, a certain number of Japanese born in Hawaii have been registered also as Japanese subjects and, formally, hold a dual allegiance. The privilege of American citizenship is not extended to all people born in territories under United States control. The people of American Samoa and of Guam, for instance, are not American citizens; the former are American-protected persons, and the latter American nationals and citizens of Guam. In the British sphere, there are a large number of British subjects, natives

as well as Europeans; but perhaps half the people under British control are not subjects but protected persons—as in the Solomon islands or the mandated territory of New Guinea. In Tonga the people are subjects of the Tongan kingdom, which is under British protection. As a very broad estimate, there would appear to be about 700,000 British subjects in the Pacific islands, about 300,000 American citizens and the same number of Dutch subjects, about 130,000 Japanese subjects, and about 40,000 French citizens. The remainder of the population, or rather more than half the total, comes into the category of protected persons under one or other form of political control.

Composition by Sex and Age

Statistical data are far too scanty to allow of any analysis of the Pacific islands population as a whole on the basis of sex and age composition. But material for some groups, such as the Hawaiian islands and Fiji, is fairly adequate, and is examined in detail in the regional sections of the Handbook (vol. II, pp. 329–332; vol. III, pp. 147–8). The general situation as far as native populations are concerned seems to be that there is a fairly normal distribution for sex and age groups, though there is apt to be some excess of males (Tongans and Nauruans, for instance, recently have shown 13 males for every 12 females). There is commonly also a high proportion of children and young people. As compared with a theoretical norm of 30·5% of the total population for an under-15 age group and 25% for an age group from 15 to 29 years, the corresponding figures for American Samoa in 1940, for example, were 45·4% and 27·2%; for Guam in 1940, 44·8% and 25·4%; and for Fiji in 1936, 38·3% and 26·3%. These proportions are evidently representative of high fertility and high infant mortality rates, but do indicate a tendency for the population to increase.

For those elements of the population which in the past have depended largely upon immigration more disproportion is observable. In Hawaii, for instance, in the earlier stages of foreign settlement there was a marked excess of males in the white population, and this is still the case with some immigrant groups, notably the Filipinos, who have relatively few womenfolk in the territory. It is also marked, though to a less extent, among the 'Other Caucasian' (i.e., the main European and North American) group, largely due to the great body of military personnel in the islands. Among the Japanese, however, this disproportion, formerly very high, has tended

to decrease during the present century, as male immigration tended to decline, large numbers of Japanese women were brought in, and the Japanese population was increased mainly through births in the territory. A more normal sex and age distribution is now being evolved for all groups in the territory. The situation in Fiji is very similar to that in Hawaii: the Fijian and mixed-blood populations show a fairly normal sex and age distribution, as do the Hawaiians and Hawaiian mixed-bloods; the Europeans, like the 'Other Caucasians', show a preponderance of males in the medium age groups, and a small percentage of children; the Indians, like the Japanese in Hawaii, show some excess of males in the higher age groups, but this excess is a progressively diminishing one, and both have a large proportion of children.

Trends of Native Population

The three most marked features in the movement of Pacific islands population, in general, are: the former decline of the native population, succeeded in recent years by a tendency to increase again; the rapid growth of the immigrant population and its tendency to stabilize itself as a permanent element; and the emergence of a mixed-blood population of increasing numbers and proportion.

When Europeans entered the Pacific islands the native population was possibly about 3½ millions, or about twice that at the present time. (This figure is no more than a guess, since the data given by early observers vary greatly in their accuracy and are often demonstrably wide of the mark.) For the greater part of the nineteenth century reliable census records are mostly lacking, but all available information then and later shows that in most island groups there was a heavy decline of population, which in some cases continued well into the present century. The Table on p. 345 gives an indication of the position in five important groups.

The general situation indicated by the Table is symptomatic for most of the Pacific islands; native population declined or remained practically stationary for a period of sixty years or more, but in recent years has on the whole tended to increase again, this increase becoming progressively more marked in the last decade or so. But the process has been by no means uniform. Hawaii has been an exception. There the decline of the full-blood native population still continues. Moreover, if the high proportion, perhaps one-third, of people who class themselves as full-blood Hawaiians but are actually of mixed blood be eliminated, the decline is still

Trends of Native Population during a Century

Island Group	Native Population						
	early 19th century	late 19th century	1900–1	1911	1921	1931	recent
Fiji	(1840) 133,500	(1891) 105,800	93,397	87,096	84,475	93,414	(1940) 104,872
Hawaiian islands	(1836) 108,579	(1891) 30,000	26,500	23,700	23,723	22,310	(1939) 21,165
Western Samoa	(1839) 46,600	(1886) 30,000	32,815	33,500	33,336	42,296	(1939) 55,558
Tonga	(1840) 18,500	(1871) 22,000	20,019	21,172	23,759	27,700	(1938) 32,490
New Caledonia	(1860) 30,000	(1891) 23,090	17,128	16,297	15,621	16,821	(1936) 17,091

Based mainly on: (1) S. H. Roberts, *Population Problems of the Pacific*, pp. 86-112 *passim* (London, 1927); (2) F. M. Keesing, *Modern Samoa*, p. 33 (London, 1934); (3) R. R. Kuczynski, *Colonial Population*, p. 21 (London, 1927); (4) A. W. Lind, *An Island Community*, p. 91 (Chicago, 1938); (5) F. M. Keesing, *The South Seas in the Modern World*, p. 308 (London, 1942). The figures for the Hawaiian islands for 1891, 1900–1 and 1911 are calculated from Lind's graph; all the nineteenth century figures given above are only estimates.

more marked. In New Caledonia there has been little change in the native population since the beginning of the present century, but it appears that a slow but steady movement of increase has now been established. In Fiji, the decline was long in being arrested, but once it was checked the population increased rapidly, though it has not yet risen to the early nineteenth century level. In Tonga, population remained almost stationary for the greater part of the nineteenth century, but in the present century it has shown a steady rise, and the 1840 total has now been considerably exceeded. In Western Samoa, despite a decline in population during the middle of the century, the situation is now somewhat similar.

What the Table cannot bring out is the extent of the decline in the Pacific as a whole in the nineteenth and part of the twentieth century, and its effects on many individual native communities. A number of these were reduced to a small fraction of their former strength, and some were practically wiped out. In the southern

New Hebrides, for instance, the mean population of Aneityum in 1865–70 was about 1,700; by 1905–10 it had fallen to about 400. That of Eromanga in 1890–5 was about 2,000; by 1915–20 it had fallen to 575. In the Solomon islands, the population of Vanikoro, estimated at about 3,000 in 1882, had fallen to 81 by 1922; that of Ontong Java, estimated at about 5,500 in 1907, had fallen to 558 in 1939. In the Marquesas, valleys which had a population of several thousands at the beginning of the nineteenth century, had only a dozen or so inhabitants at the end of the century, and some were complete'y deserted. Of three small islands off Espiritu Santo, in the northern New Hebrides, in 1905 one island had about 70 inhabitants, another 20 or 30, and the third 12; by 1925, without recruiting or emigration, the first had only one original inhabitant and 9 immigrants, the second had only recent immigrants, and the third had no population at all.

It was data of this kind, reinforced by the fairly general decline of native populations in the Pacific as a whole, that gave rise to the opinion that contact with European civilization was fatal to the native peoples, and that extinction must be their ultimate end. Happily, these views have not been borne out by more recent experience in the majority of islands. The Table has shown the position in some of the more important groups. But the populations of many others also have shown a rising trend, and in some a pressure of population upon the land has even begun to manifest itself. In the Cook islands, a population of 8,518 in 1906 has grown to 12,246 in thirty years. In Niue, there was a similar though smaller increase in the same period, from 3,822 to 4,104. In American Samoa there has been a rise from 5,799 in 1900 to 12,962 in 1940; in Nauru a rise from 1,164 in 1923 to 1,761 in 1940; in the Gilbert and Ellice islands a rise from 28,005 in 1921 to 32,574 in 1936. All these islands suffered, some severely, from depopulation in the nineteenth century. Even in the Marquesas it is possible that the tide has turned. It was stated in 1927 that 'it is almost certain that, before the next decade has run its course, not a solitary Marquesan will survive'. Yet since 1924 there has been a small excess of births over deaths, and the total population (including about 150 non-natives) has risen from 2,225 in 1926 to 2,283 in 1931, and to about 2,400 in 1936. Recently it has been reported that the population of one island, Uapou, has doubled in the last two decades. However, the 'native' Marquesan population is really a mixed one, with Tahitian and other island strains as well as some European and Asiatic admixture, so

that the situation resembles that of the Hawaiian islands, where the full-blood population is steadily declining and is being replaced by an increasing mixed-blood group.

Causes of Decline and Increase of Native Population

There has been much discussion of the cases of the decline of the native populations of the Pacific islands, and a wide range of diverse factors has been suggested as responsible. In one of the most exhaustive inquiries, that of the commission appointed in 1893 to examine the decrease of the Fijian population, a total of 36 causes for the decline was advanced. Some, such as lack of sanitation, unskilled midwifery, epidemic diseases, improper infant feeding, yaws, and the wearing of clothing, laid the emphasis on unhealthy conditions. Others blamed the culture and habits of the people—their communal system, polygamy, consanguineous marriage, cohabitation of parents during the suckling period, and general mental apathy and insouciance of the native mind. Inquiries into the situation in other parts of the Pacific added yet other reasons for the decline, such as: native wars; abortion and infanticide; difficulty of conception by native women; heavy recruiting of labour, and the abuses often attending it; alcohol; tinned foods; the practice of magic; malaria; tuberculosis.

There is no doubt that in individual cases nearly all of the physical factors had some effect, and the results of some of them were very marked. In Fiji, for instance, an epidemic of measles in 1875 resulted in about 40,000 deaths out of a population estimated at about 150,000; one of whooping cough in 1884 resulted in about 3,000 deaths; one of influenza and whooping-cough in 1891 resulted in 1,500 deaths. In the central Pacific and Western Pacific the labour traffic was responsible for heavy loss of population on some of the islands. From Nukulaelae in the Ellice group, for instance, labour raiders from South America soon after 1860 took about 300 people from a population estimated at only 400, and other islands suffered almost to the same extent. To Nukulaelae on this occasion none of the people returned, but even when the labourers did come back, their numbers were often heavily depleted by disease. Native warfare also took its toll at an earlier period; from this cause the estimated population of 18,500 in Tonga in 1840 probably represented a decrease of several thousands from the population figure of fifty years before. Again, alcoholism in the Marquesas and other islands of Eastern Polynesia and malaria in the Western Pacific

helped to reduce the population by increasing the susceptibility of many of the people to disease.

But while these and other factors caused a *fall* in population, by themselves they could not be responsible for a *continued decline*; normally, the numbers should rise again after the temporary check, or the population should acquire a resistance against them.

Moreover, among all the factors advanced it was difficult to find any which could be held responsible in all cases. Even where warfare and recruiting had ceased, where health conditions had apparently been improved, where the initial virulence of epidemic diseases had died down, and where polygamy and other traditional forms of the old native social organization had been largely swept away, populations in one or other group of islands still continued to decrease. A reduced death rate seemed often only to be accompanied by a diminution in the birth rate, and the population could not even maintain itself. In many cases it appeared that a process of progressive masculinity was at work, with the proportion of females in the populat on becoming less and less, thus lead ng to a decrease in the general capacity of the population to reproduce itself.

In the light of this, other reasons for the decline were sought. One, of a fairly crude type, attempted to shift the onus from the changed conditions due to European contact on to the inherent vices and lack of virility in the native society itself. It was argued that the islanders were a decadent stock; that the race had lost its stamina; that Europeans did not cause the decline—they merely accelerated it. This view rested on very slender evidence, and has received little support. Another, of a more subtle kind, has much more weight, and is still a matter of argument. It emphasizes the relation between the stability of a people's institutions and the values which give point to their existence. It suggests that in the face of the general disorganization of their culture after contact with Europeans the native peoples tended to lose their hold on life, found little to strive for in the new conditions, were attacked by *la grande misère psychologique*, and as a result became more susceptible to disease and less interested in or capable of producing children. Allied to these psychological factors were also the physical results of disturbance of people by labour recruiting, concentration into reserves, etc., which upset their ordinary arrangements for marriage and reproduction.

These explanations in turn, however, have not been found adequate to clarify the population situation fully. Peoples whose traditional

forms of life have been radically altered still manage to maintain or increase their numbers; others who still largely retain their institutions and who cannot be said to suffer from any notable lack of interest in life or in having children continue to decline. Statistically, a progressive increase of males in a population must in the end lead to its extinction, but increased masculinity may be only a temporary phenomenon, and in some Pacific islands populations the balance already appears to have redressed itself to some extent.

Such considerations have led to some revision of opinion, and though psychological factors and the manner of adaptation of a people to changing cultural conditions are regarded as probably having some bearing on the population situation, more emphasis now tends to be placed on the physical factors affecting fertility and mortality, in particular infant mortality. Here, though the conditions are still obscure, it seems possible that more subtle elements are concerned than was suspected earlier—that, for example, parasitic infestation and avitaminosis may be of some importance not only in affecting the general health of the people and rendering them more susceptible to other diseases, but in actually reducing fertility.

Thus, the modern approach to the problem of maintaining and increasing Pacific islands population is largely from the standpoint of an integrated improvement of social and economic conditions—better food, better hygiene and medical services, and the creation of a stable, well-adjusted community organization which not only allows the normal functioning of marriage and family life but also provides incentives for economic effort and the bringing up of children.

The reasons for the increase of many Pacific island populations during the last few decades are still not very clear but it does seem that much of the progress is in fact due to such improvement in material conditions. This is illustrated by the Fijian population: over a period of sixty years there has been little change in the crude birth rate, which in fact has fallen slightly, on the average; but the general death rate has been rather more than halved, and the infant mortality rate has fallen to less than a quarter. Thus averages for 1881–91 were: birth rate, 38·5 per 1,000; death rate, 42·8; infant mortality rate, 451 per mille of births. Corresponding averages for 1933–41 were: 36·1; 20·2; 106. It seems then that here the change from a declining population to one showing a marked increase is due primarily not to any radical improvement of fecundity but to improvement of conditions for survival of the population, in

particular of the infant population. Analysis of such crude vital statistics is not conclusive, since they must be interpreted in relation to changes of sex and age distribution, for which adequate data are not available. But this situation, which can be paralleled from other Pacific populations, does appear to have some significance.

Trends of Immigrant Population

The increase of immigrant population in the Pacific islands during the last century has already been noted. This process has taken place at very different rates, and often for different reasons, in the various island groups and among the various elements of the population. In many of the smaller islands or groups the number of persons of immigrant origin is very little larger now than it was about the middle of last century, whereas in Fiji, Hawaii and the Marianas it has shown a very marked growth. In the Hawaiian islands, for

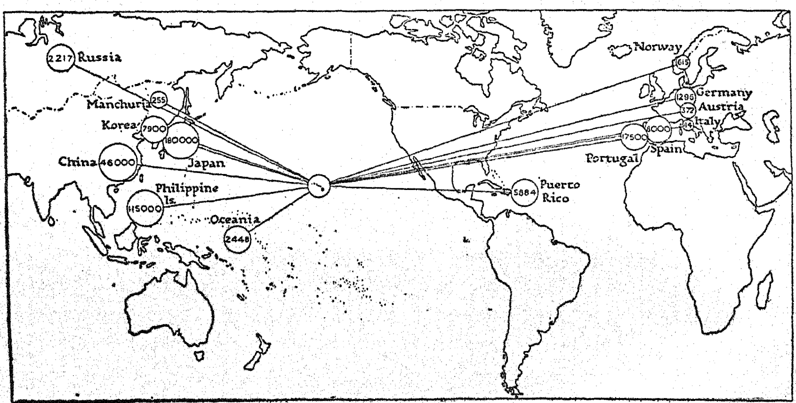

Fig. 98. Sources of immigrants into the Hawaiian islands, 1853–1933
Immigration from the U.S.A. and from the U.K. are not shown. The polyglot character of the population is clearly brought out. Based on A. W. Lind, *An Island Community: Ecological Succession in Hawaii*, p. 194 (Chicago, 1938).

instance, the number of 'foreigners' resident in 1853 was only 2,119, of whom only 202 were locally-born; by 1940 the number of people of immigrant origin was about 400,000, well over half of whom were locally-born. The attractions of Hawaii drew immigrants from a wide range of countries, both European and Asiatic (Fig. 98) as well as American.

As far as the population of European origin (including the large

element from the United States) is concerned, the major increase has taken place in the Hawaiian islands; from about 1,400 in 1853 the numbers rose to about 40,000 in 1910 and were over 100,000 in 1940. In the remaining Pacific islands the increase has been slow. Figures for the numbers in the nineteenth century are often not available, but in 1911 the total was in the region of 28,000, whereas by about 1939 it had risen only to about 33,000. The most marked increase was in New Guinea, stimulated mainly by mining development; in New Caledonia, which provided roughly half the European population of the islands apart from the Hawaiian group, a slight decrease had taken place. The European population as a whole is essentially a transient group, recruited largely by continued immigration; it is predominantly a male population, and the proportion of children born and remaining in the islands is comparatively small. This is the case even in the Hawaiian islands, where apart from the Portuguese the ratio of European *kamaaina* ('children of the land') to European *malahini* (recent arrivals) has increased only slightly over nearly a century. The Portuguese are an exception. Their immigrants included a large percentage of women and children, and the ratio of those locally-born in Hawaii to the total Portuguese group rose from about 46% in 1896 to 85% in 1930. Unlike almost all other European groups except a relatively small number of French in New Caledonia and British in Fiji, they have taken root in the islands.

The Asiatic populations on the other hand have not only grown more rapidly but have tended to establish themselves more firmly in the islands. Their increase in some areas has been most marked. In 1852 about 300 Chinese were brought into the Hawaiian islands as plantation labour; by 1900 about 45,000 had arrived, and less than half of these had returned to China, giving a Chinese population of 25,742; by 1940 the Chinese population was 28,774. An unbalanced sex ratio in the immigrant labour group hampered the establishment of the Chinese for many years, but by 1939 86% of the people of wholly Chinese ancestry in the Hawaiian islands were locally-born. Elsewhere in the Pacific the numbers of Chinese are comparatively small, and as a rule the immigration of Chinese women has been discouraged, so that there has been no great natural increase (except in some areas by mixed marriages). In New Guinea, Western Samoa, Nauru and Ocean island the recruiting of Chinese male labour has in recent years been very carefully controlled and limited, and there is little if any rising trend.

The Japanese population has shown a most notable increase in the Hawaiian islands and in the islands mandated to Japan by the League of Nations. Immigration began into the Hawaiian islands effectively in 1884, and in the succeeding period about 180,000 Japanese entered; of these just over 40% remained as settlers. By 1910 the Japanese population was 79,675; by 1940 it had grown to 157,905, largely by natural increase. In 1940 about 77% were locally-born. But the rate of increase now appears to be slowing down. In the Marshall, Caroline and Marianas islands the growth of Japanese population has taken place almost entirely during the last thirty years, after Japan assumed control of the area. Whereas in 1914 there were only about a couple of hundred Japanese in these islands, by 1939 their numbers had grown to more than 73,000. Unlike their situation in the Hawaiian islands, however, where for a long time immigration was maintained at a ratio of about four men to one woman, with an almost negligible proportion of children, that of the Japanese in these Micronesian islands held every prospect of rapid biological increase, about 40% of the immigrants being female. If there is no disturbance of this population after the war, then, it is likely to form an important nucleus of Japanese expansion in the Pacific islands.

Another large immigrant group, the Filipinos in the Hawaiian islands, have progressed more slowly towards an established position. From 1907, when Filipino labourers were first brought in, to 1934, when immigration was in effect stopped, about 120,000 Filipinos came to the islands. More than half of these returned home or went to the United States. Nearly 90% of the immigrants were males, and by 1930, when there were about 63,000 Filipinos in the territory, only about 16% were locally-born. By 1940, however, the population was moving gradually towards a more normal sex ratio, and about 32% were locally-born by that date.

The other large Asiatic group in the Pacific islands is that of the Indians in Fiji. Their numbers grew rapidly by immigration from 1879 onwards, there being about 7,500 in 1891, 17,000 in 1901 and over 60,000 in 1921. The proportion of women was on the average about one-third. Most of the immigrants preferred to remain in Fiji and some of those who were repatriated returned; despite the unfavourable sex ratio the natural increase was rapid. By 1921 about 44% of the Indian population was locally-born, and by 1936, when their total numbers had reached nearly 85,000, about 72% of them were locally-born. By this time the sex ratio was about five

men to four women. The Indian population in Fiji is now on the whole a youthful one, and further rapid increase seems probable.

TRENDS OF MIXED-BLOOD POPULATION

It is difficult to generalize about the trends of the mixed-blood population in the Pacific islands since, as mentioned earlier, accurate records of the number of such people are often impossible to obtain. But it seems fairly clear that in Polynesia especially, their numbers are tending to grow rapidly. We may consider, for instance, only those who are recognized as mixed-bloods by social or legal standards. In Fiji, their numbers have doubled in less than thirty years, from about 2,400 in 1911 to nearly 4,900 in 1938; in Samoa, they have more than doubled in twenty years, from about 1,400 in 1921 to about 4,000 in 1940; so also in Tonga, where they have increased from 235 in 1921 to 477 in 1938. Some of this growth in numbers may be due to the classing as mixed-bloods of people earlier regarded as natives, but the proportion is probably not large, and it is also possible, on the other hand, that the offspring of some mixed-bloods who have married into native families may have been entered under the native category. In Fiji about three-quarters of the people in this mixed-blood category are of European-Fijian ancestry, while most of the rest are descended from Europeans and either Polynesians or Melanesians from other island groups than Fiji. The majority of the mixed-bloods in Samoa and Tonga are of European-Polynesian ancestry. But there is also a small element of Indian-Fijian origin in Fiji, while in Western Samoa the census of 1936 showed nearly 900 persons of Chinese-Samoan ancestry.

As far as the mixed-bloods of European ancestry in these areas just mentioned are concerned, it is in general rare for them to be nowadays a first-generation cross. Most are the offspring of mixed-blood parents, or of one mixed-blood parent and one full-blood (commonly native) parent. Third-generation and fourth-generation crosses are now not unusual, and where successive marriages back into one parent stock have occurred, the present generation is biologically far removed from the other parent stock. Incidentally, there is no sound evidence to support the view that a 'half-caste', the offspring of a mixed marriage or of any combination of parents with different 'racial' traits, is biologically inferior to the offspring of 'pure-blood' stock. It appears that where, as sometimes in the past, they have shown greater susceptibility to disease, this is due

to the less favourable social conditions in which they have been brought up.

The most notable centre of ethnic mixture in the Pacific islands has been Hawaii, where not only European-Hawaiians ('Caucasian-Hawaiians') and various types of Asiatic-Hawaiians, but also European-Asiatics and crossings of all these have emerged, and are increasing in numbers. It is difficult to analyse the trends of that mixed-blood population accurately, partly because of an arbitrary census classification of the offspring of triple European, Asiatic and Hawaiian ancestry as Asiatic-Hawaiians. But the total number of persons recognized as mixed-bloods in the Hawaiian islands has risen from about 18,000 in 1921 to more than 42,000 in 1939. The number of 'Asiatic-Hawaiians' alone has risen from about 12,500 in 1930 to about 21,500 in 1939; in the earlier period these were mainly the result of unions of Chinese and Hawaiians, but at the present day they include some Japanese-Hawaiians and a considerable number of people of mixed Chinese, Japanese, European and Hawaiian ancestry. In general, there is a steady infiltration of alien strains into the 'full-blood' Hawaiian population, so that a process of substitution is taking place.

This process is at work also in varying degree throughout the whole of the Eastern Pacific; Tahitians, Tuamotuans, Marquesans, Samoans, even Tongans and Cook islanders, have all undergone some admixture with immigrant elements. It seems probable that in a century or so the number of 'pure' Polynesians will have become very small, and that almost imperceptibly the population will have become a mixed-blood one, though culturally retaining many of its Polynesian characteristics. In the central and Western Pacific the process of admixture is proceeding much more slowly, and the native population seems likely to maintain itself as a separate biological entity for a much longer period.

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Further references, including those to official statistics of population, will be found in bibliographical notes in the later volumes of this Handbook.

Chapter XII

PEOPLES: GENERAL CHARACTERISTICS

Social Conditions: Physical Types of Native People; Origin, Migration and Settlement of Pacific Islands Peoples: Native Languages: Use of Native Languages: Pidgin English: Bibliographical Note

Popular impressions of the peoples of the Pacific islands, even though clarified somewhat by accounts published in connection with the war in the Pacific theatre of operations, are still apt to seize on the extremes—the people are thought of either as languid folk, leading an easy life of pleasure among their coconut palms or on the sunny lagoons, or as savages of the jungle, practising head-hunting and cannibalism. The truth is less simple. Head-hunting and cannibalism still exist, but only in remote areas which the visitor is rarely, if ever, likely to see, and the vast majority of the people are peaceful, hard-working agriculturists or fishermen, largely concerned with making a living. The main difficulty in getting to know them is that their language and social organization vary greatly in different areas, so that what the visitor learns in one island or group may not help him much when he goes to another. The account given in this and the next Chapter is necessarily brief; further details will be found in Chapters IX, X, XI, XIV and XV of this volume, as well as in the regional volumes of this Handbook. Throughout, it should be borne in mind that much study has still to be made of the physical types, languages and culture of the native peoples, that information about the social conditions of the immigrant peoples is still also far from complete, and that the war in the Pacific has brought about many changes of which the effects cannot yet be estimated.

SOCIAL CONDITIONS

Conditions of life in the Pacific islands, for the most part, are those of frontier communities, still often in the pioneering stage. In some areas of the Western Pacific—as in some larger islands of the Solomons and New Hebrides, and notably in parts of the interior of New Guinea—the work of exploration has still to be completed. But elsewhere, too, the processes of settlement and expansion by immigrants are still continuing. Even where some degree of

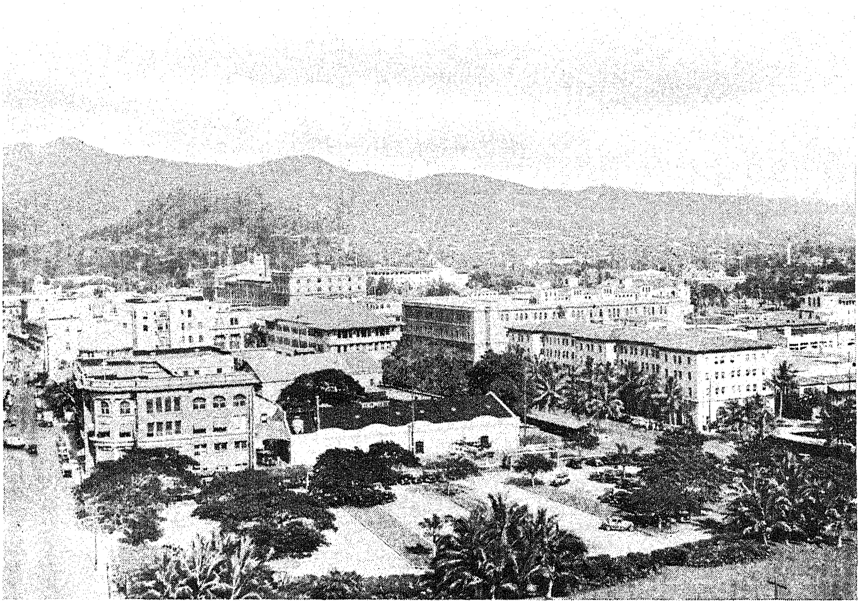


Plate 85. Honolulu, 1936
A view looking inland, showing the wide streets and large modern buildings of the leading city of the Pacific islands.

Plate 86. Bulolo, the principal gold-mining settlement in New Guinea
Showing the houses of the European residents. These are built of wood, with shady verandahs, and are raised well off the ground ; they are typical of bungalows

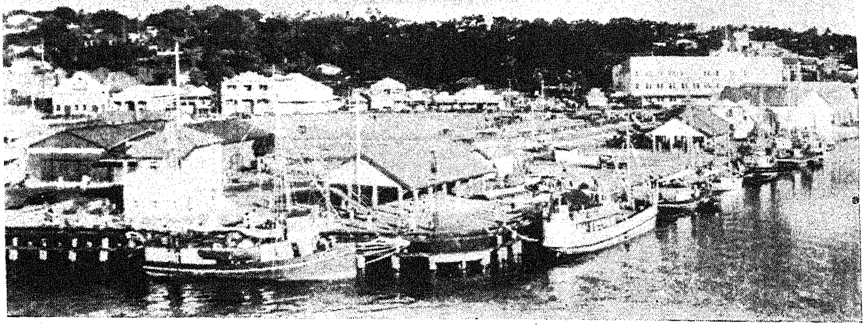


Plate 87. Suva, Fiji, seen from the quayside
The white building on the left is the Harbour Master's office. The flat-roofed white building in the right background is the Burns, Philp store.

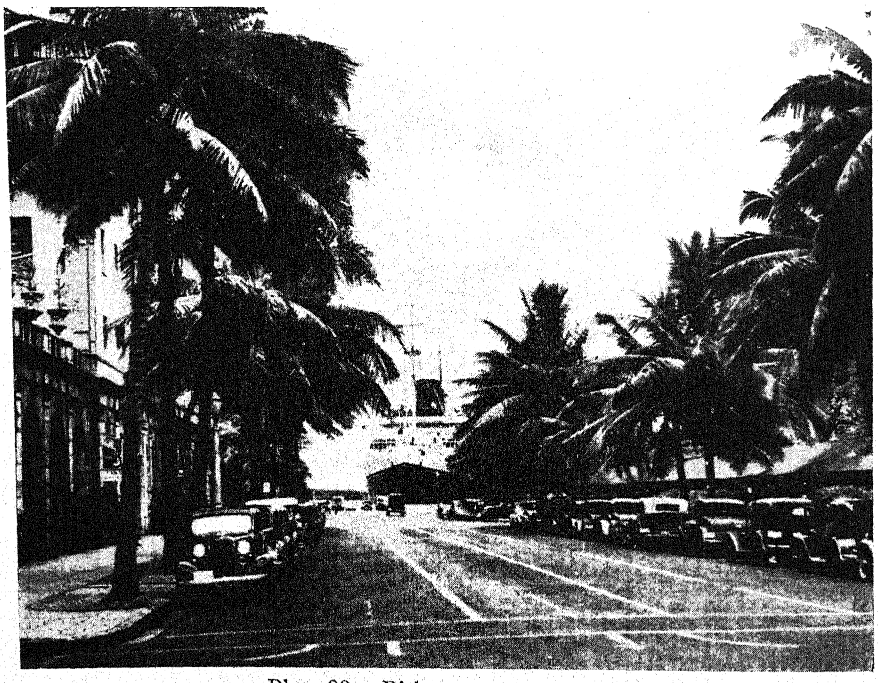


Plate 88. Bishop street, Honolulu

stability has been reached, the emphasis is largely upon the theme of development.

The Frontier Situation

An observer in many of the Pacific islands is usually struck at first sight by the newness—even the rawness—of so much of the man-made scene, and its impermanent character. He sees that the ports are usually small, with few facilities (Plates 87, 89). When he lands from his ship he may set foot on a concrete or stone pier, but more often he will have to use a rough wooden landing stage, clamber from a surfboat on to the edge of a reef, or be carried ashore on a sturdy native back. In the towns he will see solid buildings of Western style (Plate 85), but he will also note many of wood, due for replacement after a couple of decades. In the rural areas, wood is the rule for European buildings (Plate 86), and native houses often use such non-durable materials as bamboo, palm leaf or grass (Plate 90). Even when buildings such as houses or churches are in European style, they often have thatched roofs of palm leaves (Plate 92) or other native features. In distinction to the well-ordered fields, hedges and stone walls of the Old World, which give the impression of long-continued human effort and nature well kept in place, the agricultural scene of the Pacific islands displays a newness of tillage, crops always threatened by invading weeds and undergrowth, a somewhat ill-defined jungle-fringe just beyond the edge of cultivation. The European plantations, small in comparison to the area of the surrounding forest, are kept in order only by unremitting labour; the native gardens often shift from year to year and the abandoned clearings are soon overgrown; the native orchards of palms and fruit trees are often so mingled with shrubs and creepers that they are hardly distinguishable from the forest. Where mining has been developed, buildings and plant are usually of fairly recent installation, often on sites hacked out of the virgin jungle, with all the signs of pioneer industry.

This frontier situation is least evident in the Hawaiian islands, where settlement has become much more firmly established than in most of the other island groups, and where Honolulu, the chief city, is comparable in size, style and diversity of interests with the cities of New Zealand. Even here, however, the predominantly plantation and tourist economy dictates much of the life of the territory. Honolulu itself, with its wide palm-fringed streets (Plate 88), its bungalows surrounded by bright shrubs, its mixture of races, its *lei*

for visitors and other somewhat self-conscious adaptations of Hawaiian customs, retains and even stresses many of the characteristics of a tropical 'island' community.

Social Position of Ethnic Groups

The relative numerical strength of the main components in the Pacific islands population has already been described in Chapter XI. In terms of the general social situation the white people are the most active element. They are the most potent agents of change, the bearers of a new culture to the native peoples; they are the most race-conscious; they furnish both the major drives for economic exploitation and the most ardent efforts towards social welfare. The Asiatics, while assisting in this role to some degree, are in general content to take advantage of the conditions created for them in the first instance by the whites. Many of them, or of their parents, were brought to the islands by the European or American need for labour, and though they have often emerged from the status of manual workers into that of independent artisans or traders, they still respond to the basic economic and political processes rather than direct them. The native peoples are on the whole a passive element. They are the recipients of the new culture. Sometimes they take it unwillingly, sometimes they welcome it with enthusiasm. In some areas, as in the Hawaiian islands, they have taken part in the general social life fairly fully, side by side with the immigrant groups. In others, such as Tonga, they have accepted much of what has been offered but still prefer to retain their own cultural individuality and to work out new adaptive forms for themselves as far as they can. In other areas, again, they await what comes, interested in certain externals of the changing situation and keen for some material benefits, but leaving the initiative in adaptation primarily in the hands of the immigrant groups. Generally speaking, this condition is characteristic of much of the Western Pacific, where there are many peoples whom civilization has only begun to touch, and whose reactions have barely passed beyond the stage of initial respect for the wealth and technical achievements of the white man and somewhat grudging and uncomprehending obedience to his strange dictates. A special part in the whole situation is played by the mixed-bloods. In some cases, either as individuals or as groups, they have become alined with the whites. In others, they are in effect a part of the native community. In still other cases they tend to form distinct groups of their own, leaning on the whole towards

Plate 89. Tulagi, Solomon islands, before the war

The principal port of the British Solomon Islands Protectorate, showing the 'Chinatown' section of the settlement. Buildings were of wood and corrugated iron. Port facilities were confined to a few small wharves and jetties.

Plate 90. Mountain village, Fiji

A typical example of the simpler type of native village without a men's house or distinctive house for a chief. In the more accessible areas, throughout the Pacific, the native building materials—thatch on a light wooden framework—have been

Plate 91. Native church, north-west Upolu

Such buildings, constructed mainly on European lines, but usually of local materials, are a feature of areas where European mission influence has been long established.

Plate 92. Thatching, Guam

The constructional principles of the timber-framed houses resemble in some ways

the European way of life, but because of colour discrimination or for economic reasons remaining at some distance from it. But one function which they have often fulfilled is that of a bridge between the native and the European cultures, providing some leadership and assistance for the former and some interpretation and channels of communication for the latter. They often tend to occupy positions of intermediate economic and social status. However, as the native communities have become more adapted to the new conditions, this role of the mixed-bloods has tended to decline in importance and in some ways they are the element of greatest instability in the general situation.

The greater part of this Chapter and the whole of the next deal with the native peoples, who not only form by far the largest proportion of the Pacific islands population but whose characteristics, with their wide range of differences, are least familiar to visitors to the islands. The remainder of this section therefore deals with the conditions of life of the other peoples, especially of the whites (who, since they are nearly all ultimately of European origin, may be termed for convenience Europeans).

Conditions of Europeans

European conditions in the islands reflect on the whole both the frontier situation and their political and economic dominance in it. This is shown in the first place by their occupations. A large number of them are government officials, engaged in administrative duties, or in the medical, agricultural, legal and other services. Professional men in private practice are few. A large number also are missionaries; proselytization is still one of the most important European activities and is accompanied by much educational and other welfare work. Another large group of Europeans are commercial men—plantation and mine managers and their assistants, managers and clerks of trading and shipping establishments, and a diminishing number of smaller private traders. Artisans and mechanics are still few, but their numbers are increasing as urban amenities, mechanization and industries develop. Masters and officers of vessels, wireless telegraph operators and other experts in transport and communications are also a small but important group. The Europeans occupy most of the leading posts in the economic life. As a rule they do not engage in manual labour, but control that of natives or Asiatics, many of whom also now fill secondary administrative and clerical positions.

In the more stabilized communities—as in the Hawaiian islands, Tahiti, Fiji and New Caledonia—and in the towns generally, the wives and children of the Europeans usually share a great part of the life of the menfolk. But elsewhere family life tends to be interrupted for long periods, especially when it becomes time for children to be sent to school. In most of the islands the European community is predominantly a male one. It is apt also to be a fluctuating one. Though often deeply attached to 'the islands' and to their homes there, the men—especially the officials—are frequently transferred from one post to another. They prefer as a rule to spend their leave in Australia, New Zealand, or some other temperate country, and they usually retire there finally when their active work is done. A few of the larger islands, however, do have permanent European residents, some being members of families which have been established there for several generations.

Material conditions of life for Europeans in the towns are fairly comfortable, but in the rural areas many amenities are lacking. The houses, sometimes of stone, brick or concrete, but more commonly of wood, are light and cool. They are raised off the ground to allow free circulation of air underneath, and are normally of bungalow type, with wide verandahs and overhanging eaves The wooden floors are bare, or are covered only with leaf mats, which are cooler than carpets. Most of the furniture is of cane or light wood, with little upholstery, and long lounge chairs allow of relaxation in the heat. Some of the towns and a few of the industrial settlements are provided with electric light, fans and refrigeration, but elsewhere the typical bungalow has only oil lamps and no cooling facilities—except perhaps ice once a month or so, when the steamer calls. Water is rarely laid on, and some simple form of bucket shower, hand-filled, provides the equivalent of a bath. Mosquito net and water filter are usually necessary aids to health, and frequent changes of clothing, facilitated by the daily laundry, are advisable for comfort. One of the difficulties to be overcome is the monotony of the food. In some of the towns, or on plantations which keep cattle, fresh meat is obtainable, and sometimes fresh milk and butter. But as a rule tinned foods are the staple. Vegetables of European type are usually scarce, and, though native vegetables can often be had, they are commonly regarded as inferior. In most areas, attempts have been made in recent years to improve the supply of vegetables, but the climate often does not favour European varieties. Contrary to what one might expect, fish does

not appear on the menu a great deal, partly from conservatism in organizing supplies and partly because even on the coast it is not always easy to obtain. Cooking for Europeans is done as a rule by natives, whose imagination and training have usually given them only a very limited range of recipes.

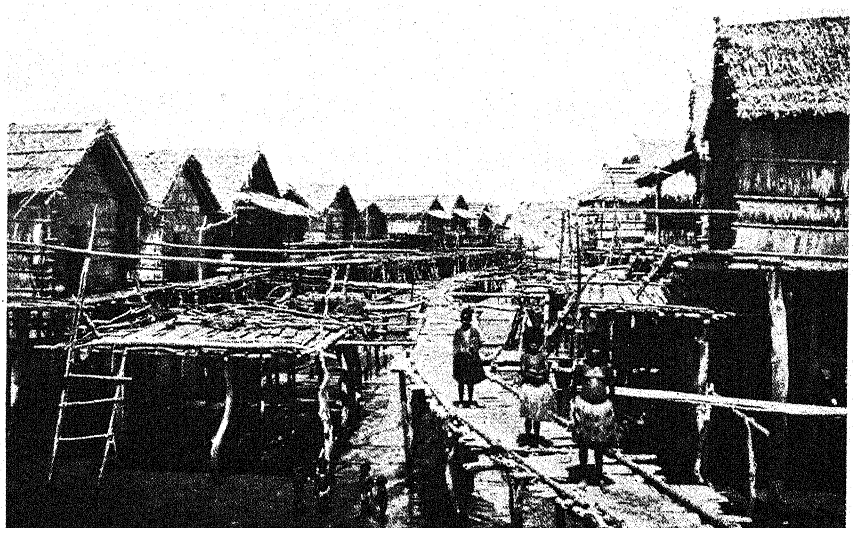
One of the advantages of the life in the islands is the abundance of labour for domestic service, which is attractive to natives; the average European man or woman is thus relieved of most of the petty duties which fall to his or her lot outside the tropics. On the other hand, a great drawback is the comparative isolation. To some degree this is now mitigated by the radio, but in many islands mails are infrequent, newspapers are a month or so old when received, and even urgent messages may take several days to deliver in the rural areas by launch, canoe or carrier. In the more isolated islands a trader, planter or missionary may spend several months without any personal communication with the outside world. In the towns and other settlements this isolation is of course much less severe. Though cut off from many wider contacts the community organizes its own social life, in quite elaborate, often formal fashion, with dinners, sport and 'the club' as the foci. Honolulu has a fully-fledged city life and Suva, Noumea, Papeete and a few other towns have cinemas, libraries and museums, and publish newspapers and periodicals.

One of the characteristic features of the life of Europeans in these tropical islands, however, is their relative lack of close contact with the Asiatic and native peoples. Race discrimination of an overt kind receives little formal expression, and in the Hawaiian islands, despite an attitude of reserve on the part of the white Americans, social and biological mingling of races has taken place to a marked extent. But usually, owing partly to difference of interest, partly to difference in cultural and economic levels, and partly to some amount of colour prejudice, contacts are largely confined to business occasions, and there is little real social intercourse between members of the different communities. To this rule there are exceptions, especially among government officials and missionaries. But the very fact that the language normally used by Europeans is English (or French in the French areas), 'pidgin English', or a restricted and modified form of a native vernacular, tends to act as a barrier to any deep understanding of the ideas of the natives or the Orientals, many of whom can still converse fluently only in their own tongue.

Conditions of Asiatics and Mixed-bloods

Conditions of Asiatics and of mixed-bloods (both Asiatic-native and European-native) tend to vary more widely in the different island groups than do those of Europeans. In the islands held by Japan under mandate, the Japanese were in a unique position, resembling in many respects that of Europeans in the other island groups. They were the dominant political element, they excluded other peoples, they undertook an extensive immigration programme, and they directed development and trade into channels most favourable to Japan. Their social standards and way of life remained essentially those of the homeland, simpler than those of Europeans, but generally higher than those of the natives. In the Hawaiian islands, members of the Asiatic communities have attained social and economic status equal in some cases to that of the white Americans, though on the whole they occupy positions of less importance, and their living conditions are on a lower grade. Here the Chinese in particular have shown a marked tendency towards assimilation of American ways of life and have become absorbed in large measure into the general islands community. Elsewhere in the Pacific islands Chinese and Japanese, especially the former, have become fairly well identified with the local life. They usually occupy an economic and social position intermediate between Europeans and natives. Their dress usually approximates to that of Europeans. Their housing is apt to be simple—rough, somewhat ramshackle wooden buildings—with few amenities. Their food, which is usually good, retains many of its national characteristics—with much use of tea, fish, vegetables and (with the Chinese) pork. The Indians in Fiji have also carried the process of adaptation quite far. Emerging to a considerable degree from the condition of a manual labouring class, they have become peasant farmers, artisans and traders, with a sprinkling of professional men. Their social conditions have improved considerably during the present century, and among other benefits they have secured representation in official posts and on a variety of public bodies. Some of their traditional ways of life still obtain, but others have suffered great change. The caste system has been greatly modified, allowing freedom of occupation and uninhibited personal contacts between people of different castes. Women are no longer veiled or secluded and they do little work in the fields. The men have virtually abandoned Indian dress, and the women have modified it

Plate 93. Hula, a village on the Papuan coast, south-east of Rigo
These pile-dwellings are typical of coastal villages in south-eastern Papua. Formerly they gave protection from enemies ; they still give some relief from the swarms of mosquitoes which frequent the beaches.



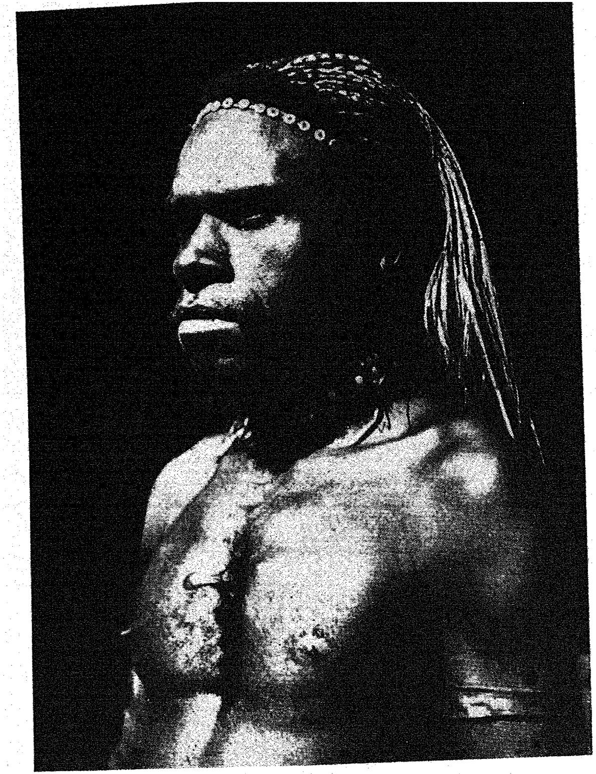


Plate 95. A native of the Morehead district, Papua
An example of a Papuan physical type. Note the elaborate hairdressing.

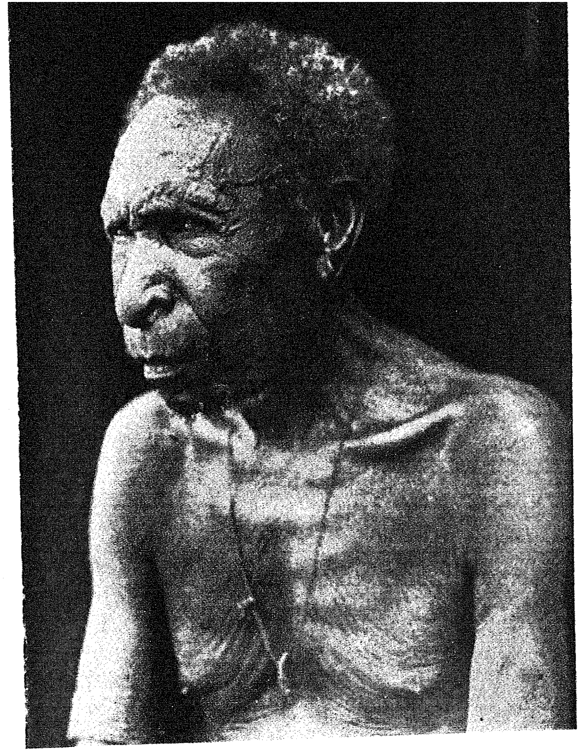


Plate 96. A Papuan elder
Haio, an elderly member of the men's house of Avavu, on the coast of the Gulf of Papua.

considerably. Their food, however, is still of the basic Indian type; it includes rice, pulses, milk and *ghee* (clarified butter fat). Their relations with Europeans and with Fijians are still somewhat distant, though they are on a more friendly footing with the latter, and a small amount of ethnic intermixture has occurred. In general terms, they have adapted themselves to the island life, but have not been fully assimilated into a wider corporate existence.

PHYSICAL TYPES OF NATIVE PEOPLE

Much scientific work still remains to be done in describing and classifying the physical types of the native peoples of the Pacific islands, in analysing the influence of environmental and racial factors, and in separating groups classified on a physical basis from those classified on a cultural or linguistic basis. But broadly speaking, five main racial groups of people may be distinguished. Three of these, the Negritos, the Papuans and the Melanesians, are usually regarded as belonging to the great Negroid division of mankind; they inhabit the major part of the Western Pacific. Another group, the Polynesians, belong to the Caucasoid division; they inhabit the central and Eastern Pacific. The last group, the Micronesians, seem to belong mainly to the Mongoloid division; they inhabit the north-western part of the Pacific islands. This classification, however, is made only in the most general terms. Each of the groups shows considerable variation in skin colour, stature, shape of the head and face, type of hair and other physical characters, and none can be regarded as being at all of a pure racial type. Moreover, quite apart from their earlier history, there has clearly been appreciable physical admixture between some elements of these groups in the Pacific during the last few hundred years. The Micronesians in particular appear to be much more mixed than the others.

Negrito

The peoples of the Negrito type in the area (sometimes spoken of as Oceanic pygmies) have a comparatively limited distribution, though they are fairly closely related to the pygmy Aeta of the Philippines, the Semang of Malaya, the Andamanese, and (more distantly) to the 'pygmies' of equatorial Africa. In the Pacific, they occur mainly in central New Guinea, though they are also found in the interior of Espiritu Santo (New Hebrides) and in a modified form in a few of the islands in between. Their most

characteristic features are their small stature, short woolly hair, round heads and broad noses. The Tapiro, Pesechem and Nogullo 'pygmies' of the Nassau mountains of Dutch New Guinea, for example, who are among the most typical Negritos, have a normal stature for adult males of only 4 ft. 9 in. The Tapiro have short black hair, abundant on face and body, yellowish-brown skin colour, straight noses of medium breadth, and deep convex upper lips. Their heads are mesocephalic (a medium ratio of head breadth to length—in this case the index being slightly under 80). The Negrito of the Goliath mountains, who are somewhat taller, are brachycephalic (broad-headed, with an index of over 82). Elsewhere along the central range of New Guinea are a number of peoples of mixed Negrito and Papuan physical type; their average stature ranges on the whole between 4 ft. 11½ in. and 5 ft. 2 in., which, though low, puts them outside the ordinary 'pygmy' groups. All these people tend to be of stocky build, with good musculature.

Papuan (Plates 95–8)

The Papuans, inhabiting the greater part of New Guinea (except in the south-east and on parts of the coastal fringe) as well as some of the islands immediately adjacent, are of very varied type. In general the hair is black and frizzly or woolly, and often quite long; it grows abundantly on the face. The skin is of a dark chocolate colour to sooty-brown. The head is typically dolichocephalic (long in relation to its breadth, with indices below 77) though there is local mesocephaly in some areas. It is usually high, with retreating forehead. Brow ridges are usually prominent, and prognathism is common. The nose is often large and convex, with the tip turned down, giving rise to a popular description of such people as having a 'Semitic' look. The stature of the Papuans is one of their most variable characters, and it has been suggested that this may be a reflection of the differences in their environmental conditions. In general, their average height is low. For instance, the Kwoma, a mountain-dwelling people north-west of the Sepik river, have an average stature (for adult males) of 5 ft. 4 in., and the people in the villages along the Sepik are of much the same general height. Those in the Waria and adjacent valleys range from about 4 ft. 11 in. to about 5 ft. 8 in., with an average stature of about 5 ft. 2 in. In the Papuan gulf, however, the people are much taller. A sample of Orokolo men gave a range from 5 ft. 3 in.

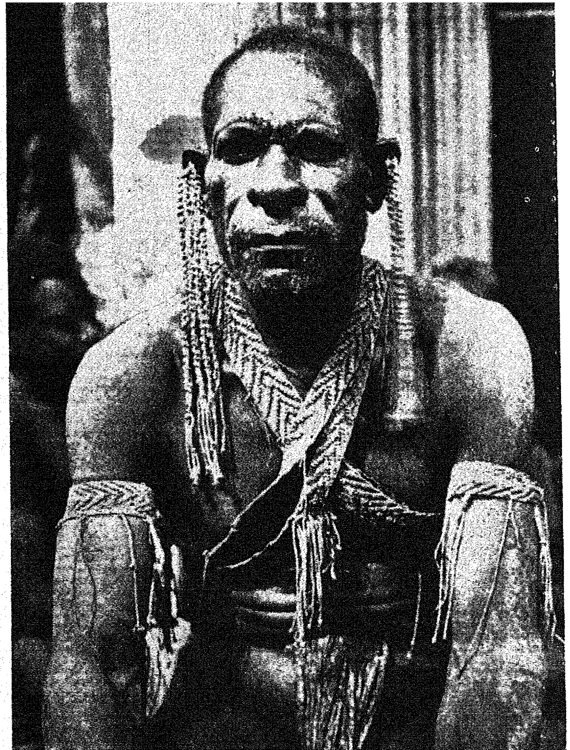


Plate 97. A Papuan in mourning for a dog
The man is smeared with mud as a sign of grief; Papuans often hold their dogs in high regard.

Plate 98. An old man from the Orokolo bay area, Papua
The pierced nose septum and ears often hold ornaments. Armbands are a common decoration.

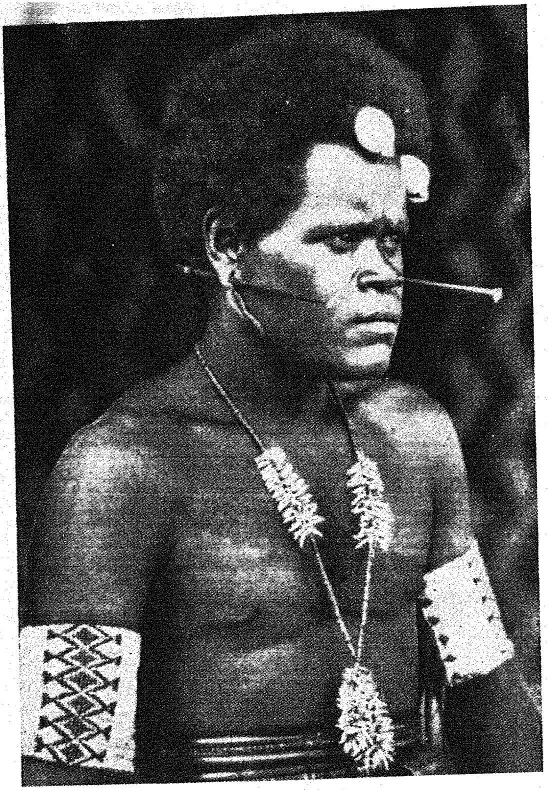


Plate 99. A youth, north Malaita, Solomon islands

A typical example of a Melanesian with frizzly hair, dark skin and broad nose. Note the wealth of shell and other ornaments.

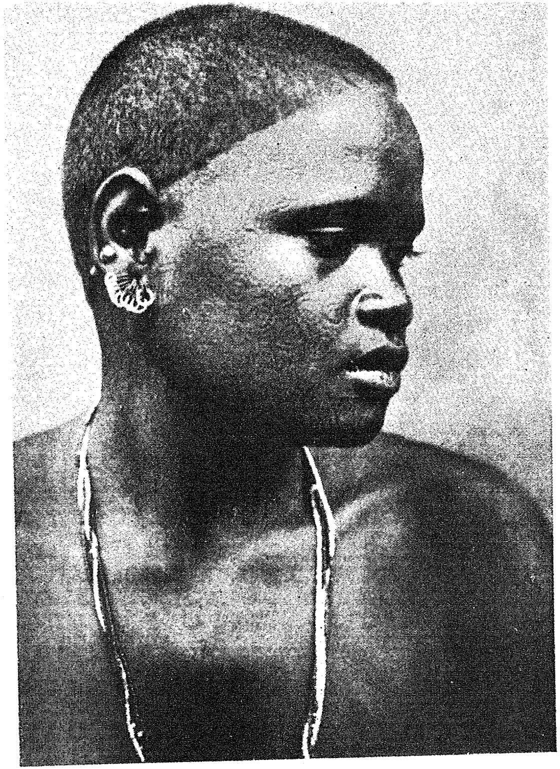


Plate 100. Young girl, the southern Solomon islands

Formerly, girls in this area used to have designs cut in their faces with a sharpened fishbone.

to 5 ft. 11 in. with an average of 5 ft. 7½ in., and the people of the Purari river are of similar stature.

Melanesian (Plates 99–104)

The Melanesians, inhabiting the south-eastern part of New Guinea, and nearly all the islands between New Guinea and Fiji, are of even more varied type. They are regarded as springing from Papuan stock, but mixed with immigrant strains. The hair is dark (though sometimes bleached to a light hue with lime), and is usually frizzly, but is sometimes curly or even wavy; it is normally less abundant on face and body than that of Papuans. The skin colour is commonly a dark chocolate, but may be of a bronze tint or even, as in the case of the Mailu (of south-eastern New Guinea) or the Pokao (inland from Hall sound), a light brown, almost *café-au-lait* shade. Both these peoples, as also others on the eastern side of the Papuan gulf, show great diversity of hair type; that of the Pokao is often curly or wavy, being almost circular in cross-section instead of elliptical, which is the typical section of the frizzly Papuan hair. In the Solomon islands, though the hair is almost uniformly frizzly, the skin colour varies from a very dark brown, almost black, in the western part of the group, to a light brown or bronze in the eastern part. Throughout the Melanesian area, dolichocephaly is common. Examples are: an average cephalic index of 75 (the range being 70–81) among the Pokao; of 76 (the range being 71–81) among the Motu; of 75 at Milne bay, with approximately the same value elsewhere on the eastern end of New Guinea; of 75 in the Siwai district of Bougainville; of 75 or less in Malekula in the central New Hebrides. But much broader heads are also common in a number of areas. The Roro and Mekeo peoples west of Port Moresby have average cephalic indices of 79 and 83 respectively. The Massim peoples of eastern New Guinea and the islands immediately adjacent show a fairly regular gradation in head form from dolichocephaly to mesocephaly as one moves from west to east. As against average indices of about 75 at Milne bay, Wagawaga, Tubetube, etc., the index rises to an average of 79 in the Louisiades, 80 in the Marshall Bennet islands and about 81 in Murua. In a few areas, as around Möwe harbour in the south of New Britain, and in parts of Malekula in the New Hebrides, the form of the skull is affected by artificial deformation, which tends to give a high elongated shape (Plate 101).

The Melanesian face is commonly broad, with forehead somewhat

rounded, and brow ridges usually not very prominent. The nose is broad and usually fairly straight, being smaller and less curved than that of the Papuan. But in some areas, as for instance in south Malekula, a type with long face, rather high forehead and somewhat hooked nose may be seen (Plate 102) and the brow ridges may be well marked (Plate 104). In some cases, as among the Pokao, slightly oblique eyes have been noted, possibly suggesting a Mongoloid trait. The lips are usually of medium thickness. Prognathism is uncommon, and where it exists is slight, but a retreating chin is not infrequent.

The stature of Melanesians, like that of Papuans, is very variable, though really tall people such as are found in some Papuan groups rarely occur. On the whole, short or medium stature is the rule, with averages between about 5 ft. 1½ in. and 5 ft. 3 in. The average stature of the Motu, near Port Moresby, is about 5 ft. 4 in.; that of the Roro and the Mekeo is about 5 ft. 2½ in. and 5 ft. 3½ in. respectively; that of Pokao men is about 5 ft. 6 in. At the eastern end of New Guinea, the men of Fergusson island average about 5 ft., those of Tubetube about 5 ft. 1 in., those of the Marshall Bennet islands about 5 ft. 2 in., those of the Trobriands about 5 ft. 3½ in. and those of Murua about 5 ft. 4½ in. The Solomon islanders have an average stature of a little over 5 ft., while in the New Hebrides averages of 5 ft. 3 in. to 5 ft. 5 in. have been recorded. In Tana, in the southern New Hebrides, where Polynesian intermixture seems evident, the average height of the men is about 5 ft. 5 in. and about 20% of them are between 5 ft. 6 in. and 5 ft. 7½ in., with about 10% taller still.

Polynesian (Plates 106–8)

The Polynesians inhabit the greater part of the central Pacific and the whole of the Eastern Pacific. In general they have straight or wavy hair, tall stature (with averages of 5 ft. 6 in. to 5 ft. 9 in. for men), and broad heads. The face is fairly broad and massive, and the forehead is usually high. The nose is large and prominent, sometimes convex but more usually straight, and the lips are moderately full, often with a firm, well-chiselled appearance. The chin is well developed, but prognathism of the jaw is almost entirely absent. The eye colour is dark brown to black. There is no very marked development of brow ridges. Some Polynesian peoples, as for instance those of the Society islands and the Marquesas, show traces of the epicanthic fold of the eyelid, which gives a slanting, Mongoloid appearance to the eye, but with others, as the Samoans

Plates 101–4. Melanesian types from Malekula, New Hebrides
Plate 101 (top left) shows the effects of head deformation in childhood. Note the pronounced brow-ridges, dark skin, frizzly hair and broad noses.

Plate 105. One of the twelve hereditary chiefs of Yap

An example of the Micronesian physical type ; he is wearing a wooden comb in his hair as a symbol of his rank.

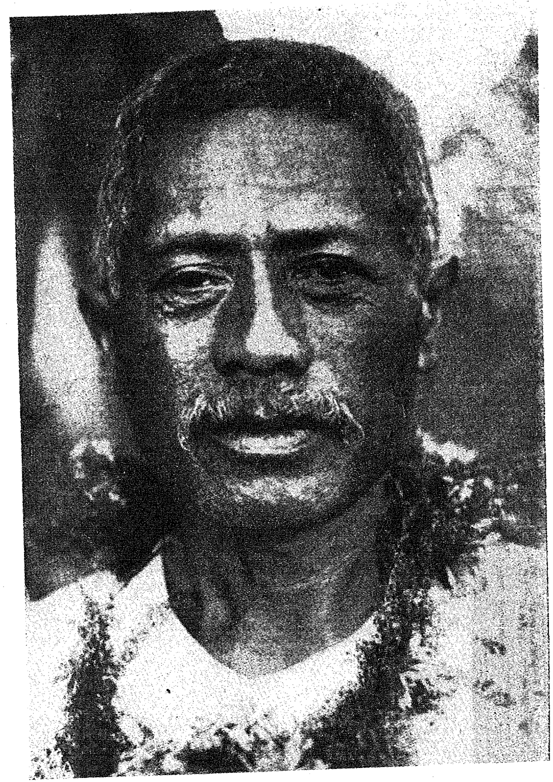


Plate 106. A Hawaiian

A typical Polynesian. He is wearing around his neck a *lei* or garland of flowers.

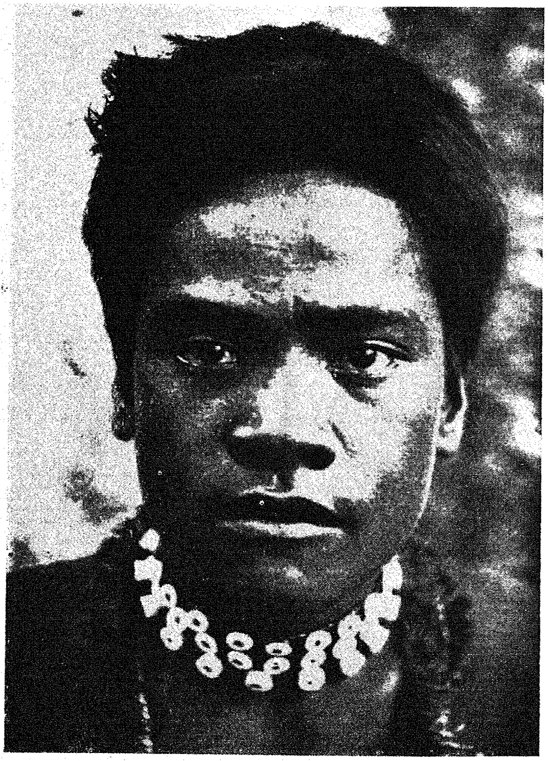
and the Cook islanders, it is almost entirely lacking. The skin colour is light, being usually of a pale to moderate brown, and in some cases it is about the same shade as that of southern Europeans. There is little development of hair on the body, though it is of moderate growth on the face. On the whole, the Polynesians are of solid build, with well-moulded limbs and good musculature; they often show a tendency to corpulence in middle age.

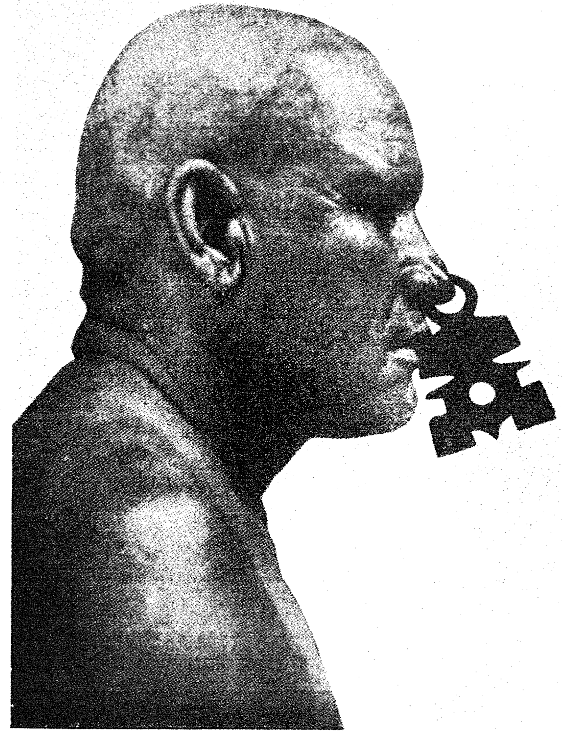
The Polynesians are more homogeneous as a racial group than either the Papuans or the Melanesians. But they are clearly of mixed origin, and various attempts have been made to distinguish different stocks among them. According to one view, for example, two main types may be recognized. The first has a taller stature, more slender build, longer head and higher face, more open eye, narrower and higher nose, thinner head, straighter hair which is more abundant on face and body, and a comparatively light skin colour; the head is mesocephalic. The second type is shorter, rather broader in most measurements, darker in skin colour, and possibly of Mongoloid affinities; the head is slightly brachycephalic. Both types are distributed throughout Polynesia, but the first is regarded as being more prevalent in the south and the second in the north and centre. According to other views there are more than two basic types, and the sets of characters by which each type is recognized are somewhat differently arranged. But these views rest mainly upon a procedure of analyzing mixed populations, identifying selected traits or characters and then re-combining them somewhat arbitrarily to obtain the basic types. The tendency has been also to extend the hypotheses further and associate each type thus picked out with a specific migration into Polynesia. Such procedure is not scientifically of much value, especially since from the genetical point of view it is still uncertain whether a mixture of such types would in fact have given a population with those physical characters shown at the present time. Studies of the geographical distribution of the average values of a number of physical traits, however, do indicate that whereas in some traits, e.g., stature, there is a remarkable uniformity among all Polynesian groups, in other traits, e.g., cephalic index, there is considerable variation. The variations in cephalic index show a fairly well-defined geographical pattern. The Society islands stand out as an area of marked brachycephaly, with a mean index of about 85; the people of Hawaii, the north-western Tuamotu atolls, the Austral islands and some of the Cook islands have indices which approach this closely. In Samoa, Tonga, the central

Tuamotu atolls, the Marquesas, and Mangaia, Manihiki and Rakahanga (the last three in the Cook group) the mean indices are rather lower, ranging from about 81 in Samoa and Tonga to about 79 in the Marquesas. In some of the more isolated islands, as in Napuka (on the north-eastern fringe of the Tuamotu archipelago), in the south-eastern Tuamotu atolls, in Mangareva and in Easter island (and also among the Maori of New Zealand), the mean indices fall to the dolichocephalic level. In Easter island the average is 74.6 and in Napuka it is only 74.3. From this fundamental uniformity of the Polynesians in some characters and variation in others it has been inferred that they are a people of diverse origins, but that the component elements had already emerged before migration into Polynesia began. The evidence does not support views that the area was settled by a number of migrations with each successive wave constituted by people of a distinct physical type.

Apart from the broad variations mentioned, there are certain local differences worth noting. One of these is the extreme brachycephaly found in some individuals, especially in those areas where the mean cephalic indices are high. Indices of 90 and above occur. In such cases the head is apt to be unusually broad, with a markedly flat back to it—'alasame timber', as a native once commented in pidgin English. It has been stated that this phenomenon is due to artificial flattening of the skull. But though the heads of infants are deformed by binding in some parts of New Britain and the New Hebrides, such a custom does not normally obtain in Polynesia, and the curious shape of the head there appears to be a hereditary characteristic.

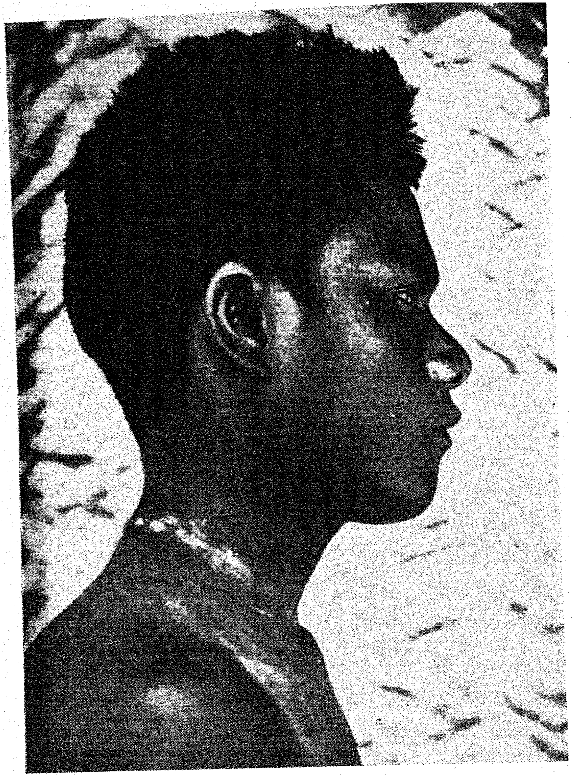
Other types of differences are due to recent race mixture. As already mentioned in Chapter XI, the Polynesians in practically every island group have undergone some degree of miscegenation with Europeans and Asiatics, with the result that individuals are often seen who diverge very widely from the general type described above. Racially speaking, they are hybrids. But the 'foreign' admixture has often taken place several generations ago, and the offspring of that union have since married back into the native group. Since their children and grandchildren do not stress their alien ancestry and behave as ordinary members of the Polynesian community, without careful inquiry one may conclude that Polynesians are much more variable in physical character than is in fact the case.

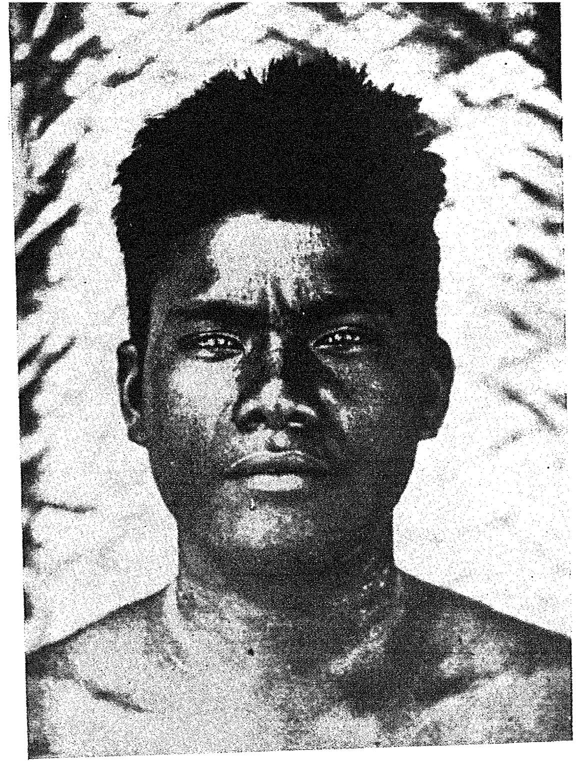




Plates 107, 108. Two representatives of marginal Polynesian communities

On the left (Plate 107) is a youth of Nukumanu ; on the right (Plate 108) is a man of Ontong Java. Both places are atolls on the northern fringe of the Solomon islands. The turtle shell nose ornament is characteristic of Ontong Java.





Plates 109, 110. A youth of Ontong Java

Profile and full-face studies of a member of one of the marginal 'Polynesian' communities of the Western Pacific. These peoples, though possessing predominantly Polynesian cultures, are of mixed physical type with a Micronesian strain.

Micronesian (Plate 105)

Comparatively little exact information is available about the physical characters of the Micronesians, but it would seem that they are a very mixed population. In fact, though the term Micronesian is often used to denote a physical type in Oceania, it is doubtful if the people constitute a distinct racial group as the Polynesians, Melanesians, etc., may be said to do. In the absence of precise data, however, it is still convenient to speak of them in this way. In general they are people of moderate stature, fairly light brown skin, wavy or curly hair, narrow noses and moderately thin lips. But there is considerable variation, especially as one moves from east to west. In the east the people of Jaluit have an average stature of 5 ft. 5 in. (for men), and have heads of moderate length and width, with a mean cephalic index of 77. The people of the Gilbert islands have rather longer heads and are taller, with an average stature (for men) of 5 ft. 6½ in. Towards the west, however, stature is less on the average, being about 5 ft. 4 in. to 5 ft. 5 in. in Kusaie and Ponape, about 5 ft. 4 in. in Truk, and 5 ft. 3½ in. to 5 ft. 4 in. in Palau. Head form also shows a somewhat similar variation, from the dolichocephaly of Kusaie and Ponape (average cephalic indices, 74–76) and of Truk (72), to the mesocephaly of Yap (average cephalic index, 78) and of Palau (79–82). Whereas again in the east, practically all the people have wavy or straight hair, in the west some have hair of this type, but a large proportion have curly hair, and nearly 10% have frizzly hair. In general, the people of the west appear to be rather more closely related to those of Malaya and Indonesia than are those of the east of Micronesia.

Classification of Border Groups

The general characters of the five main racial groups in the Pacific islands have been outlined above and their broad distribution indicated. There are, however, a number of communities, especially on the Polynesian border, which offer a special problem in classification. These include the people of Fiji, of Tana, Eromanga and some other islands in the southern New Hebrides, and of Tikopia, Ontong Java (Plates 108–10), Nukumanu (Plate 107), Kapingamarangi and other islands on the fringe of the Melanesian area.

In physical type, the people of Fiji appear to represent a Polynesian-Melanesian cross (though in language and culture they belong much more definitely to the Melanesian group). In stature, with a range of 5 ft. 2 in. to 6 ft. 3 in. and a mean of 5 ft. 7 in., they

closely resemble Polynesians and so also in cephalic index, in which they show a range of 68 to 94, and a mean of 82. In characters of the face, the Fijians stand in general between Polynesians and Melanesians, though in breadth of face they fall within the Polynesian range, and in breadth of nose within the Melanesian. In skin colour and type of hair they are linked most closely with the Melanesians. The people of the southern New Hebrides seem to represent another type of Polynesian-Melanesian cross. In stature they are Melanesian, being shorter than their neighbours of New Caledonia and the Loyalty islands, but their long narrow noses and long faces are a Polynesian characteristic. In head form some resemble Melanesians, but others, notably the people of Tana, have a head width which places them nearer the Polynesian type. The hair is definitely of Melanesian type, but in skin colour there is considerable variation, about 20% of the people having light brown skins.

The people of the other islands mentioned on the Melanesian fringe are often classed as Polynesian, but most of them probably are mixed populations. Those of Kapingamarangi, between New Guinea and the Caroline islands, resemble Polynesians in stature and most other measurements, though they have much shorter faces; they are most strikingly similar to the Marquesans and the Maori. The people of Tikopia show many Polynesian traits, including tall stature, extreme brachycephaly, straight or wavy hair and light skin colour. But other traits, such as the dark brown or even chocolate skin colour of some people, indicate a mixed origin. The people of Ontong Java approximate to Polynesians in skin colour and hair form, but in most other respects are non-Polynesian. In stature (5 ft. 4½ in.), in cephalic index (74) and in other head measurements they resemble most closely the Caroline islanders of Micronesia.

ORIGIN, MIGRATION AND SETTLEMENT OF PACIFIC ISLANDS PEOPLES

Two problems which have attracted much attention in the study of Pacific islands peoples are those of their origin and their dispersion. Many theories have been put forward to explain where they came from, by what routes they came, and how they managed to settle practically all the widely scattered islands over the vast expanse of

ocean between New Guinea and Easter island. Another allied problem is that of the sources of their culture.

Some theorists have tried to obviate the difficulties of oceanic migration by postulating the former existence of a Pacific continent, Lemuria (analogous to the Atlantis of the Old World), which sank in prehistoric times, leaving only the tops of its mountains and some surviving population above the sea. The stone statues of Easter island (vol. II, pp. 74–7) and other stone remains elsewhere in the Pacific have been regarded by some of the supporters of this view as the work of the inhabitants of the vanished continent, who stood at a higher level of culture than the people of today. Geological evidence, however, gives no basis for this theory, and it may be regarded as merely a fantasy.

Other more serious hypotheses, concerned with the origin of various items of culture and language, have sought to link the Pacific peoples with America or with eastern Asia. From the evidence of the distribution of certain food plants, especially the sweet potato, it has been argued that there was probably contact between the Oceanic peoples and South America, and some linguistic resemblances have also been cited in this connection. From the similar shape of certain weapons, such as short, sharp-bladed clubs, a case has been made out for the possibility of linkage between Polynesians and the peoples of the north-west American coast. Linguistic and cultural resemblances between the Japanese and the Polynesians have been pointed out, and analogies have been traced between art forms and other cultural items of the Chinese and those of various Pacific islands peoples. Relationship has been postulated between the pictographic 'script' on the wooden tablets of Easter island and the records of the ancient script found at Mohenjo-Daro on the Indus. Still more far-reaching theories have suggested connections between the social institutions, ritual and religious beliefs of ancient Egypt, Sumeria and Crete and those of some Pacific peoples. None of these theories has as yet received any widespread support. The evidence for the spread of cultivated plants—if once agreement is reached about their original home—is of some weight. But little value can be attached to the arguments which attempt to show connections between peoples who are geographically far distant, merely on the basis of a few parallels in custom, vocabulary or arts and crafts. On the whole these arguments have selected superficial resemblances, compared the form rather than the meaning of the items chosen, underestimated the importance of independent local developments,

and ignored the differences which should also demand explanation if the Pacific peoples had really had the contacts suggested.

It might be thought that some clue to the origins of the Pacific islands peoples could be given by archaeology—that, as in the Old World, excavation, by revealing ancient settlements, graves, implements and skeletal material, could show what the former inhabitants of the area were like, what mingling of races took place, and what the earlier connections were. Here, however, the results have been so far disappointing, though the negative evidence in itself is valuable. As far as investigation has gone it appears that east of New Guinea, at all events, the history of man in the Pacific islands is comparatively recent. As yet no prehistoric remains have been discovered which compare at all in age with those which have been found in Australia and in Java. Even for later periods few if any traces of peoples preceding the present inhabitants of the islands have been found. (The stone pestle shown in Plate 119, found deep underground in Papua by Europeans who were extracting gold, is possibly evidence of an earlier culture.) Little archaeological work has yet been done in Melanesia. But in Polynesia, where much material has been accumulated, no ruins or other remains have been found which represent a real break with the historic Polynesian cultures. Older theories laid stress on the former presence of Melanesian peoples in Polynesia, but this is not supported by the archaeological evidence, which does not show any traces of Melanesian culture underlying the Polynesian. Ancient structures of coral slabs on Malden island and other islands in the central Pacific, sometimes described as if they were relics of a pre-Polynesian civilization, have been shown to be temples, house sites and graves of early Polynesians (vol. II, pp. 464, 480, 488, 500). Stone statues and platforms on Easter island, often spoken of as relics of an earlier folk than the Polynesians, and wooden statuettes, sometimes thought to show Melanesian influence, have their closest analogies in the Marquesas and elsewhere in Polynesia. Incised rock-carvings (petroglyphs) found in the Marquesas may be attributed definitely to the ancestors of the present Marquesans. They have their parallels in the Easter island pictographic 'script', and both appear to be art forms characteristic of proto-historic eastern and south-eastern Polynesia. Similarly, excavations in New Zealand, so far from verifying what was once a common opinion, that the country was occupied by people of Melanesian affinities before the ancestors of the Maori arrived, have only strengthened the view that the earliest inhabitants were of a Polynesian type.

In regard to the general origin of the Pacific islands peoples, the view most commonly accepted, on racial, linguistic and cultural grounds, is that they came into the area from Indonesia, probably with south-east Asia as the further home of some of their elements. The earliest period of their arrival in the Pacific is quite uncertain, and the order of the arrival of the various types is still only a matter of tentative reconstruction, on which there is not yet complete agreement. But the broad picture may be suggested as having been rather as follows. At an early period, presumably many thousands of years ago, groups of woolly-haired people came through the Indonesian archipelago, taking advantage of the land bridges and crossing the narrow sea channels (perhaps when the sea was at a lower level than now) on rafts or in simple dugout canoes. It seems probable that there were several varieties of these people, differing in stature, skin pigmentation and head form, and their arrival may well have been separate in time. Among the earliest comers were probably people of very short (pygmy) stature, who spread out in New Guinea and reached some of the islands to the south-east; these were the ancestors of the present Oceanic Negritos. Other groups, dark-skinned, dolichocephalic and probably of very variable stature, were apparently somewhat later arrivals; they spread through most of New Guinea and down through the islands to the south-east, perhaps reaching as far as Fiji. These were the ancestors of the present Papuans. Later still came other immigrants, either light-skinned, with narrow noses and wavy or straight hair, or already mixed with the dark-skinned, broad-nosed, woolly-haired peoples. They mingled with the Papuans on the northern and eastern coasts of New Guinea and in the islands to the south-east, producing a varied range of peoples constituting the ancestors of the present Melanesians. In view of the coastal and island distribution of the Melanesians, these immigrants probably came to a large extent by sea, and may have brought with them outrigger canoes. Much later again, perhaps about the beginning of the Christian era, the ancestors of the present Polynesians began to arrive in the Pacific, possibly as the result of pressure by Mongoloid immigrants into Indonesia. The route followed by the Polynesians was formerly thought to be along the northward and eastward fringe of the Melanesian islands, but the current view nowadays is that more probably they went to the north, through what is now called Micronesia. It was also formerly held that they displaced and absorbed Melanesian populations in many of the islands, even

as far to the east as Easter island, but it now seems more likely that their admittedly mixed racial composition is due to much earlier fusion, probably in Indonesia itself. Whether the Polynesians remained in Micronesia for a long time or not is still debated. It is also a question whether, assuming they did pass through Micronesia, they managed to carry many of their characteristic food plants with them through the somewhat barren atolls, or received them later again through Fiji. (The presence of the yam, taro and breadfruit in Polynesia—all plants of Asiatic origin which occur also in Melanesia, but not in the eastern Micronesian atolls—is one of the strongest arguments for the use of the Melanesian route by the Polynesians.) The subsequent migrations of the Polynesians are discussed below. The origin of the Micronesians is somewhat more uncertain. But it is likely that as the Polynesians moved on from the Caroline and adjacent islands they were succeeded there by peoples of mixed type from Indonesia who may have intermingled with some remnants of the Polynesians.

As each of the main groups became established in the Pacific islands, processes of development of local cultures and of secondary migration began. In New Guinea and Melanesia, where genealogical records are kept for only short periods and traditions of movement of peoples are comparatively few, the evidence for such migration is largely a matter of inference from the distribution and relationship of items of culture such as types of pottery, art motifs, initiation rites and other ceremonies. From this it would appear that transmission of cultural elements and migration of peoples have taken place along two main routes—from the north to the south of New Guinea over the main range, following the courses of the great rivers; and from the Melanesian islands round the south-eastern end of New Guinea along the eastern coast of the gulf of Papua. In Micronesia there was further infiltration into the Caroline islands from Indonesia on the west, while Indonesian elements also reached the north and west coasts of Dutch New Guinea. From Micronesia also there were southward intrusions, reaching such islands as Ontong Java in the Solomons.

But the migrations of greatest scope and interest within the Pacific islands are those of the Polynesians (Fig. 99). These people were and still are great seafarers. By whatever routes they came it is indubitable that by the time of the discovery of the islands by Europeans they had reached and colonized every island group and almost every isolated island throughout the whole of the Eastern

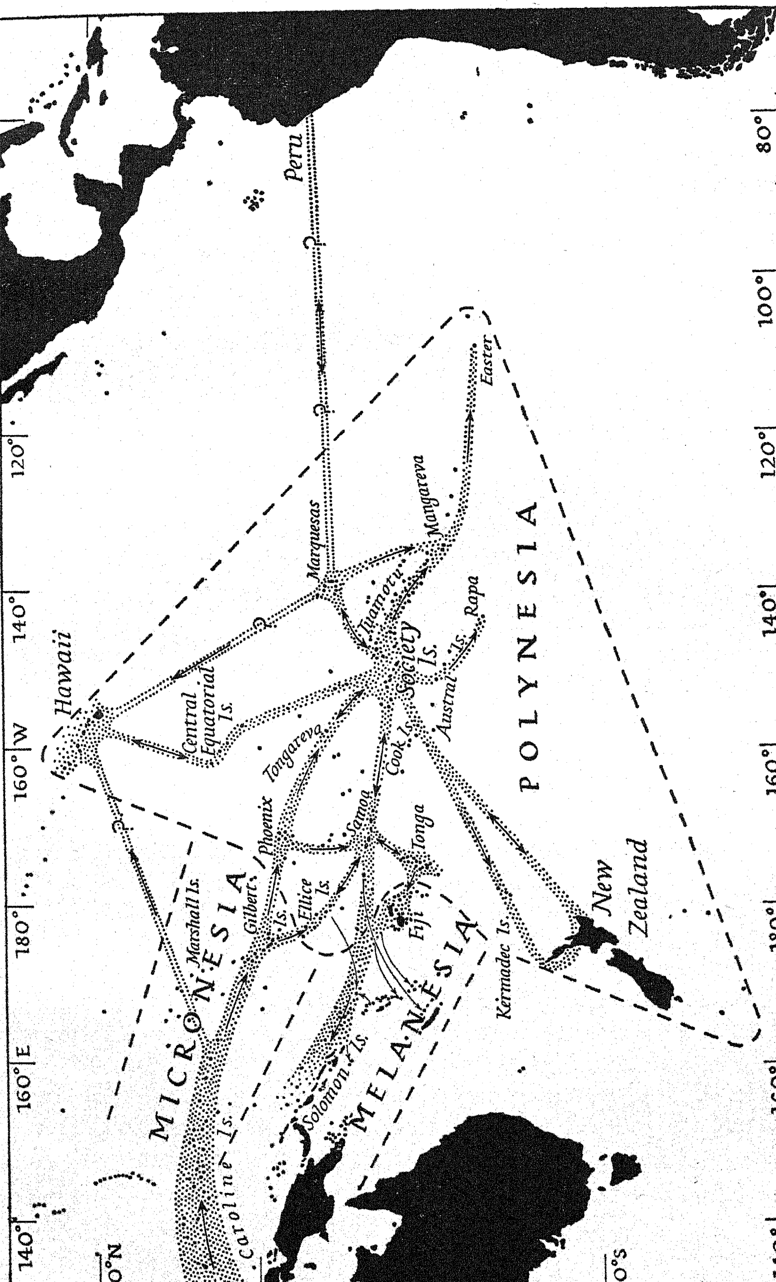


Fig. 99. Polynesian migrations

Based on a map in P. H. Buck (Te Rangi Hiroa), *Vikings of the Sunrise, end-papers* (New York, 1938).

Pacific, from Hawaii to New Zealand and from the Ellice islands to Easter island. Some of this settlement may have been the result of drift-voyages—fishermen blown away in a storm, or vanquished warriors or offenders against the law seeking a hurried escape by sea. But much of it must have been planned, because the settlers often brought with them women (who do not take part in deep-sea fishing) and also domestic animals and cultivated plants. Moreover, Polynesian legends and traditions tell of the preparations made for such voyages in search of new islands or for settlement in islands already known from travellers who had returned home. New canoes were built and stocked with provisions and water, livestock was taken, and fireplaces were laid down on beds of sand. There were various reasons for such voyages: pressure of population on the food supply; desire of a junior chief to find scope for his ambitions; flight from the wrath of an offended superior; pursuit of an enemy or of a loved relative; or the desire for exploration for its own sake. Formerly it was customary to speak of 'waves' of migration, but nowadays, when a more detailed picture had been built up, it seems more correct to regard the process as a 'stream' of successive, possibly intermittent, voyages.

In attempting to trace the routes of Polynesian migration the distribution of physical characters, cultural and linguistic features is taken into account. But an important and very special type of evidence is afforded by traditions and genealogies, which are highly developed as records by the Polynesians. Though their primary function has been in serving as a background and charter for titles to land, authority and special privileges, and as a means of expressing and bolstering up prestige, they also provide the investigator with material for historical inferences. One set of traditions, found almost everywhere in Polynesia except in the western groups, deals with the homeland from which the settlers came to their respective islands. It is known to the Maori as Hawaiki, and the same name is found in dialectal variants in Hawaii (strictly, Hawai'i), Savai'i in Samoa, and Havai'i, an ancient name for Ra'iatea in the Society islands. This gives certain migration clues, and speculation has even gone so far as to see in the name an original reference to Java (*h* or *s* naturally replacing the *j* which is not used in Polynesian, and *iki* meaning 'little'). Other sets of traditions cite the names and circumstances of the chiefs who took the lead in the main voyages, give the names of their canoes, and trace the descent of the present-day Polynesians from them. Comparison of these traditions in

New Zealand, Rarotonga and the Society islands, for instance, has shown that many of these names and details correspond, despite the long separation between the different peoples. This, with other data, has allowed the inference, almost with certainty, that one of the most important voyages of colonization to New Zealand by the ancestors of the Maori took place about the middle of the fourteenth century.

The general picture of Polynesian migration and settlement thus built up varies according to whether stress is laid on the original entry being made through Micronesia or along the more southern route through the Melanesian border. In the latter case, eastward movements from Fiji and Samoa are given great weight; in the former, these islands are regarded as being rather recipients of a westward movement. At the present time the tendency is to regard them as centres of dispersion westwards rather than eastwards. On this view, an important stream of early Polynesian migration went eastwards from Micronesia, probably through the Phoenix group and the Northern Cook islands to the Society islands, where Ra'iatea became the main centre of colonization. Another stream, passing more to the south, possibly by several routes, reached Samoa, thence spreading at an early period to Tonga and to Fiji. From Ra'iatea settlement spread through the Society islands, and thence to the Southern Cook islands, to the Austral islands, to the Tuamotu archipelago and to the Marquesas. All these groups were probably colonized by the end of the first millennium A.D. About that period, or soon afterwards, it would seem that colonists also reached New Zealand and Hawaii from the same source, while then or later Mangareva, Pitcairn and Easter island also received Polynesian settlers. Between about the eleventh and the fifteenth centuries, possibly because of expanding population, possibly because of the arrival of fresh streams of settlers from the west, a great outburst of renewed voyaging and settlement appears to have taken place. Among other movements this led to the departure of the famous fleet of canoes to New Zealand, where the voyagers found earlier Polynesians already in occupation. Later still, other voyages took place, mostly on a smaller scale, from Samoa and Tonga to islands to the west, north-west and north-east—as to Tikopia and Niue; and between many other islands—as between Tikopia and Vanikoro, or from Uvea (Wallis island) to Uvea in the Loyalty group. Contacts between Samoa, Tonga and Fiji were apparently maintained with some frequency. The people of many of the smaller

islands today claim descent from immigrants from a variety of other islands.

Migration and settlement of peoples in the Pacific in recent times are described in Chapters IX and X.

NATIVE LANGUAGES

Classification

The native languages of the peoples of the Pacific islands may be divided into two broad groups: those belonging to the Austronesian family (sometimes described by the earlier term Malayo-Polynesian) and having a definite connexion with one another in structure and in phonetics; and those ordinarily known as Papuan, the classification of which is as yet uncertain, and all of which are not necessarily related to one another. The languages of the Negritos have still to receive careful study, but what little is known of them suggests that they can probably be classed with the Papuan group.

The Austronesian languages have been recognized as comprising four branches or sub-groups: Indonesian; Melanesian; Polynesian, and Micronesian. This classification is geographically convenient but probably not linguistically final. The Indonesian languages are spoken to the west of the Pacific islands (with negligible intrusions into New Guinea) and therefore fall outside the scope of this Handbook; historically, however, they have exercised an important influence on the other branches of the Austronesian family. The Melanesian languages are distributed from the northern, eastern and south-eastern coasts of New Guinea through nearly all the islands from the Admiralty group to Fiji. The Polynesian languages are distributed from some outlying islands in the Solomons and the New Hebrides north-eastwards through the Ellice islands to Hawaii, south-eastwards to New Zealand, and as far eastwards as Easter island (the main islands of Fiji being excluded from this region). The Micronesian languages, though of wide geographical range, are spoken by a much smaller number of people; they are distributed from Palau and Yap in the Carolines northwards to Guam and the Marianas and eastwards to the Marshall islands and the Gilbert islands.

The Papuan languages are characterized by a great variety of types—it has been said that some of them are as different from one another as English is from Chinese—and the number of linguistic stocks represented by them is still unknown. They cover by far

the greater part of New Guinea (the main exceptions being parts of the coastal districts towards the east) and extend also to the interior and north-east of New Britain, the centre and south of Bougainville, and a few areas elsewhere in the Solomon islands. Because of the variety of the languages, and because the term Papuan may be misleading when applied to languages spoken far out in the Melanesian islands and not necessarily of the same family as any spoken in New Guinea, it has recently been proposed that 'non-Melanesian' should be substituted for Papuan as a linguistic category. This would have the advantage of emphasising the fact that these languages have been grouped together simply by reason of their difference from Melanesian. But a negative description of this kind is also apt to be puzzling, and until a more adequate classification has been worked out it is perhaps preferable to retain the term Papuan for them. The following description gives a few of the main characteristics of the various types of Pacific islands languages.

Main Characteristics

Papuan

Though the Papuan languages can differ so much from one another in structure and vocabulary, there are certain broad features that tend to recur in them. In general, these features render them more complicated than other types of Oceanic languages.

Nouns, for instance, often do not vary for number, though in some languages they do, by adding suffixes, by reduplication or by using separate words indicating 'many' or 'all' which follow the noun. But they sometimes show gender by regular inflections which are carried over into dependent adjectives, pronouns or verbs. In some of the languages gender as such disappears, and there are so many kinds of nouns with different forms of inflection that they have been termed 'noun classes'. Some languages in the Sepik region have about a dozen of such classes, others in Bougainville have over twenty. One class comprises words for long objects; another, words for short objects; another, words for personal possessions, etc. Thus in Nasioi, 'my chief'—(chief my) is *bauka nkana*; 'my house' (house-one my) is *pava-nava nkanava*; 'my bow' (bow-one my) is *mpa-navang nkavang*—the word for 'my' being inflected according to the class of object.

Pronouns are usually complex. As well as the ordinary singular

and plural, there is normally a dual, and sometimes a trial in addition. (The latter, however, may be regarded etymologically as merely compounds of the appropriate numerals and the plural.) There are usually also inclusive and exclusive forms of the dual and plural, and in the third person there are often variations for gender and class. Thus, to take a few examples from Monumbo—'we (two persons)' is *ip*; 'we (more than two)' is *im*; 'he' is *ning*; 'they (two persons masculine)' is *mak*; 'they (more than two, masculine)' is *ming*; 'they (two persons, feminine)' is *vak*; 'they (two things)' is *manaman*; 'they (more than two things)' is *mbok*. Possessives are often twofold, with an independent word and also a suffix added to the noun. Thus in Bongu, where the word for father is *mem*, 'my father' is *adjim memdjim*, and 'our father' (not including the person spoken to) is *gam memgam*.

The verb also is complicated by series of prefixes and suffixes which carry still further the kinds of distinction already mentioned. Thus in Monumbo, the following are sample variations:

I strike	*ek ang-ba*
I strike him	*ek ning ang-ba-t*
I strike (a) child	*ek mik ang-ba-m*
I strike (a) thing	*ek ik ang-ba-p*
He strikes	*ning nung-ba*
He strikes her	*ning uk nung-ba-k*

Faced by these and even more complex variations of the verb, a European who is listening to or reading the language may well think at first that he is confronted by quite different words for the same kind of action. Many of the Papuan languages build up their words on such a pattern, adding one type of suffix after another to a root until long compound words are formed—the process known as agglutination. Some further difficulty in grasping the languages is due to the order of their words in a sentence. The order is usually as in German or Latin, with the verb last in its clause, and words that would be prepositions in European languages normally follow their noun in Papuan languages, becoming thus 'postpositions'.

The system of numeration is not usually on a decimal basis, as is found in most Polynesian and Melanesian languages. Some Papuan languages have basic numerals only up to four, others up to three, while some have numbers for only one and two. This does not mean that the people cannot count any further than this, but that they do so by using combinations of the basic numerals, supple-

menting these by words such as that for 'hand' for five, 'two hands' for ten, 'man' for twenty, etc.

Melanesian

The Melanesian languages, unlike the Papuan, have all essentially the same structure. But the intermingling of populations and the close contact between Melanesian-speaking and Papuan-speaking peoples has meant that the Melanesian languages show great variety in vocabulary, although more than three hundred roots common to them all have been traced back to Indonesian sources. Moreover, some of them have adopted a number of the characteristics of the Papuan languages, especially on the mainland of New Guinea, where the word-order in a sentence is often that of the Papuan type.

The nouns in Melanesian languages do not normally show variation for number and gender, nor is there the elaborate system of noun-classes characteristic of many Papuan languages, with the corresponding 'concord' or agreement of adjectives, pronouns and verbs. Pronouns have dual and sometimes trial forms, and also inclusive and exclusive forms in the first person. Thus in the Kuanua language of Blanche bay there are six forms to indicate 'we'. *Dor*, *datal* and *dat* mean respectively 'you and I', 'we three', 'we (more than three)'—the person spoken to being included in each case: *amir*, *amital* and *avet* mean respectively 'I and another', 'we three', 'we (more than three)'—the person spoken to being excluded in each case.

Possession is expressed in two characteristic ways. In one, suffixed pronouns are used, but only with a group of nouns which indicate parts of the body or things which stand in a close relation to the possessor. While the plural suffixes differ considerably, those for the singular are almost universally forms such as—*gu*, *–ku* or *–k* for the first person; *–mu*, *–ma* or *–m* for the second person, and *–nya*, *–na* or *–n* for the third person. (When these suffixed forms are employed, a particle is often used before the noun. Various prefixes may also be used, indicating class, group, etc.) Thus, in Kuanua, *natu* means 'son'; *natugo*, 'my son'; *natum*, 'thy son'; *natuna*, 'his (or her) son'. In Mota, *tamai* means 'father'; *ratamak*, 'my fathers' (i.e., including father's brothers, etc.); *i tamana*, 'his father.' In Fijian, *na tamanggu* means 'my father'; *na uluna*, 'his head'; and so on. The second way of indicating possession is used with nouns in which the relationship is less intimate. Here similar suffixes to those cited above are employed,

but they are added not to the main noun but to one of a series of possessive words. The actual possessive word used depends upon the kind of action or possession implied. Thus in Fijian the suffixes are compounded with one or other of three possessive words: *no–*, the most general form, indicating ordinary possession or relationship; *ke–*, indicating a food, or something to be used on a person, or certain characteristics such as size, weight, appearance, etc.; and *me–*, indicating things drunk, or soft things swallowed. Thus in the first category are *na nona vale*, 'his house', *na nona thakathaka*, 'his work', and *na nona turanga*, 'his chief'. In the second category are *na kena uvi*, 'his yam (that he is going to eat)', *na keni dali*, 'his rope (e.g., to be used for tying him)', *na kena levu*, 'his size'. In the third category are *na mena ti*, 'his tea (that he is going to drink)' and *na mena dovu*, 'his sugar cane (that he is going to chew)'. But it may be observed that where the kind of relationship implied differs, a different possessive word is used. Thus while *na kena uvi* and *na mena ti* mean that the yam and tea are food and drink respectively for the person concerned, *na nona uvi* and *na nona ti* would imply that these things belong to him but he is not necessarily going to consume them—he may be going to keep them, sell them or give them away. Similarly in Mota, *no* indicates ordinary property; *pulai* (*pula–*) indicates property especially valued; *ga* indicates a close relationship, generally of food; and *ma* indicates things to be drunk or chewed for the juice. Thus, *nok o vetal* (literally, 'goods–my the banana') means simply 'my banana'; but *gak o vetal* (food–my the banana') means 'my banana (to eat)'. Similarly, *mak o pei* means 'my water (for me to drink)'. 'My pig'—indicating simply general possession—is not *nok o kpwoe*; the correct expression is *pulak o kpwoe*, because pigs are property of special value.

The verb is much less complex in Melanesian than in Papuan languages. In general, the form of the verb does not change to agree with subject or object. But prefixes and suffixes, which are common, are attached to the verb in order to enlarge its meaning—to make an active verb passive or transitive, or to give a verb reciprocal or causative force, etc. Thus in Fijian: *sovaraka*, to pour out, *sovaraki*, to be poured out, and *tasova*, to be spilt; *mate*, to die, and *vakamatea*, to kill; *lomana*, to love, and *veilomani*, to love one another; *lako*, to go, and *veilakoyaki*, to go hither and thither, to travel about. Many verbs are formed in this way from nouns and adjectives. Thus in Fijian: *katu*, a fathom, gives *katuma*, to

measure by fathoms (arm stretches); *tama*, father, gives *veitamani*, to be related as father and child; *mbalavu*, long, gives *vakambalavutaka*, to lengthen. Reduplication of the verb or part of it is also common, to indicate continuation, frequency, etc. In Mota, for instance, an expression such as *o aka me salesalesale sasale* may be used to describe a canoe drifting on and on. Sometimes variant reduplications bear rather different meanings. Thus in Mota, *pute* means to sit; *putepute*, to sit from time to time; *pupute*, to keep on sitting; *putpute*, to sit down closely. The tense of a verb is usually expressed not by any change in the form of the verb itself, but by a separate particle preceding it. Thus whereas in English we use 'sits', 'sat', 'will sit' according to the time of the action, in Mota the corresponding expressions are *we pute*, *me pute*, *to pute*.

The numerals in Melanesia differ from those in Papuan languages in being based mainly on a decimal system, though some systems are quinary. Nearly all the terms used may be traced back, as also may those of Polynesia, to related terms in Indonesia.

Polynesian

The Polynesian languages may be regarded as being a more mature product of the original stock than the Melanesian, having a simpler grammar and phonetics. They have no consonant groups (the sound which is represented in ordinary characters as *ng* is a simple nasal) and every syllable ends with a vowel, thus giving the languages much more euphony to a European listener. Moreover, the languages have borrowed much less from outside sources, and the vocabulary is much more uniform throughout the whole of Polynesia than it is in Melanesia; this is so much the case that the differences between one Polynesian language and another are often hardly more than dialectal. On the other hand, the strong tendency in Polynesian to eliminate consonants has resulted in a large number of homophones (words of the same sound but different meaning), so that understanding may be difficult unless the listener has grasped the whole context of what the speaker is saying. Again, processes of local differentiation have resulted in shifts in the meaning of words, or in words acquiring new meanings; therefore, while it is fairly easy with a knowledge of one Polynesian language to make oneself understood in another by using the common vocabulary, care must be taken with many of the words to see that the local meaning is employed.

In the large common vocabulary, consonantal differences between

the Polynesian languages are of such a regular kind that a series of equivalents has been worked out, enabling one to know in advance with some certainty what the form of a word is likely to be in any of the main languages. The following simplified Table indicates some of the major differences of this kind. (The vowel system differs also, but in less regular fashion.)

Maori	Hawaiian	Tahitian	Samoan	Tongan	Mangaian	Tikopian
h	h	h	s *or* f	h	‘	s
k	‘	‘	‘	k	k	k
r	l	r	l	l	r	r (l)
ng	n	n *or* ‘	ng	ng	ng	ng
t	k	t	t	t (s)	t	t
w	w	v	v	v	v	v
wh	h	f *or* h	f	f	‘	f

Thus, for example, the name for the traditional Polynesian homeland is found as Hawaiki in Maori, Hawai‘i in Hawaiian, Havai‘i in Tahitian, Savai‘i in Samoan and ‘Avaiki in Mangaian. The word for ‘ bay ’ is *whanga* in Maori, *hana* (or *hono*) in Hawaiian, *fa‘a* in Tahitian, and *fanga* in Samoan and Tongan. The word for ‘ land ’ is *whenua* in Maori, *honua* in Hawaiian, *fenua* in Tahitian and Tikopian, *fanua* in Samoan, *fonua* in Tongan and *‘enua* in Mangaian.

The large number of homophones raises difficulty for the learner of these languages, who has to rely mainly on the spoken word since the body of writing is comparatively small. Moreover, the system of writing is largely phonetic. (The comparatively few homophones which occur in English present little difficulty, since distinction is helped by the written system, which is not phonetic. Thus *sees*, *seas* and *seize*, all pronounced alike, are remembered more easily as separate words.) In Tikopia, for instance, *pa* means ‘ to thud on the ground ’ in one sense, and is a term of address to a father or paternal uncle in another sense. In the same language, *po* may mean either ‘ to touch ’ or ‘ night ’ according to context: and *pu* may signify ‘ conch shell ’, ‘ to kindle ’ an oven, or be a ritual term of address to an ancestor. The difficulty of comprehension may be increased in moving from one language to another. Thus *pa* in Tahitian may mean ‘ father ’ as in Tikopian; but it can also mean ‘ a fence or hedge ’, or ‘ to give ’. In Mangaian *pa* has the meaning of ‘ guard ’. In Tahitian, *po* means ‘ night ’ (as it does generally in

Polynesian), and also can have the significance of 'antiquity' or 'the afterworld'; the term for 'touching with the hand' is *popo*. Similarly, *pu* has in Tahitian the meaning of 'conch shell', but is not used in the other Tikopian senses, though it has several other meanings, including 'to be obtained', 'to be completed'. So also with many other words; some of their meanings are common to all or most of the Polynesian languages, while others are specific to individual languages.

Incidentally, the difficulty of ascertaining the meaning of similar words when they are written down is increased in some languages by the practice of omitting glottal stops. For example, in Tahitian, there is a series of words all written *hoi*. One of them, pronounced without a glottal stop, refers to a plant of the yam type. Two others are pronounced *ho'i*, one being equivalent to the Maori *hongi* and meaning 'to smell' or to 'touch noses' (the common Polynesian greeting), and the other being equivalent to the Maori *hoki* and meaning 'to return', 'also', etc. Here, as in other eastern and central Polynesian languages, the omission of the glottal stop in writing tends to obscure an already complex situation by suggesting homophones which do not exist in the spoken language.

In Polynesian, nouns do not have grammatical gender. They hardly ever vary for number (there are a few cases in which a lengthening of a vowel of a word indicates the plural). But number is often shown by a change in the definite article which precedes the noun; for instance, *te fare* means 'the house', and *nga fare* 'the houses'. In some of the languages the indefinite article also varies for singular and plural, but in others it does not. Adjectives, which follow the noun, do not vary. Pronouns have singular, dual and plural forms, with inclusive and exclusive forms of dual and plural in the first person. But there is no trial, as there often is in Melanesian and Papuan languages. Possession is not indicated by suffixes to the noun as in Melanesian, but by a series of possessive pronouns, etc., which precede or follow the noun according to circumstances, and which are apt to vary for singular and plural. A common distinction here is between forms with the vowel *a* and those with the vowel *o*. Their use is partly one of convention, but in general the forms with *a* indicate a more active relationship on the part of the possessor and those with *o* a more passive relationship, often of greater intimacy, but sometimes only of more general character. Thus, in Tikopia kinship, 'my child' is *taku tama*, and 'my children', *aku tama*; but 'my mother's brother' is *toku tuatina*,

and 'my mother's brothers', *oku tuatina*. *Ana nea* and *ona nea* both mean 'his things', but the former indicates that he is doing something with them while the latter merely refers to them as his possessions. In some of the languages the usage approximates to that of the Melanesian possessives described earlier; parts of the body, food, clothes, etc., are used with one form but not with the other.

The Polynesian verb is simple. It makes no agreement with subject or object, nor does it in itself vary for tense or mood, which are indicated by preceding particles. What is commonly called a passive is, however, indicated by a suffix, of which there is a variety of forms, and this 'passive' is often used where in English we should use an active construction. For example, in Tikopian, expressions such as *nai taia* (literally, 'by him struck') or *kau inumia* ('by me to be drunk') are common, instead of *ko ia ne ta* ('he did strike') or *kuou ka inu* ('I shall drink'). As in Melanesian languages, a variety of prefixes to verbs indicates reciprocity, causation, frequency, etc. Reduplication of syllables, or of the whole of a verb, is commonly used to indicate repetition or to modify the meaning; a system of suffixes is also used to provide a range of verbal nouns.

The Polynesian numerals are based on a decimal system, and can be traced back to Indonesian forms. There are in addition a group of nouns of plurality or linkage, varying in form in the different languages, which specify collections of people or things. For instance, in Tahitian, where *ari'i* means a principal chief, *hui ari'i* means 'the royal party or family'; in Tikopian, where *tangata* means 'man' and *tuatina* means 'mother's brother', *te kau tangata* means 'the group of men', and *te tau tuatina* means 'mother's brother and sister's son'. Sometimes a collective noun seems to have replaced a numeral. In Maori, for instance, *tekau*, the word for 'ten', appears to be such a collective term which has been substituted for an older word, *ngahuru*, which with dialectal variants is the general word for 'ten' throughout most of Polynesia.

Micronesian

The Micronesian languages have received less systematic study than those of the other areas in Oceania, but in general phonetics and structure they resemble Melanesian. Their vocabulary is of an individual character, but they share a small stock of common words—as for 'face', 'ear', 'hand', 'stone', 'fish', etc.—with the other Austronesian languages.

Nouns are not invariable as in Polynesian, but take a plural form by means of prefixes or by mutation. By various processes of modification nouns and also verbs are formed from adjectives. Thus in the Palau language, *bages*, meaning 'new,' gives *bleges*, meaning 'newness', and *omeges*, meaning 'to be new'; *klikid*, meaning 'clean', gives *kl'likid*, meaning 'cleanliness', and *mangikid*, meaning 'to be clean'. There is a wealth of possessive suffixes, of types akin to those used in Melanesian, and the system of pronouns is extremely complicated. The conjugation of verbs is also of a complex kind, with much modification by prefixes, suffixes, and infixes. An example of the type of change may be seen from the following, in Palau:

akureor, I am working	*ng diak 'kureor*, I am not working
ngoureor, he is working	*ng diak loureor*, he is not working
ak ulureor, I have been working	*ng dimlak 'kureor*, I have not been working
ng ulureor, he has been working	*ng dimlak loureor*, he has not been working

In general, the native languages of Micronesia have not been greatly altered by modern developments. But an exception to this is the Chamorro language. This is still used in the native homes and on the streets of Guam, but it has been much modified in historic times by Spanish, Tagalog and English.

USE OF NATIVE LANGUAGES

The casual visitor to the Pacific islands will find that in most of them he will not need to learn any native language. Over most of the Eastern and central Pacific English will serve him in the ports and settlements, and it is of course the main language throughout the Hawaiian islands. In Tahiti and New Caledonia, French is the ordinary language of communication between Europeans and natives, though a certain amount of English is spoken also. In the Western Pacific some variety of pidgin English is the usual *lingua franca*. A number of the more educated Samoans, Tongans and Fijians, however, speak perfect English. In fact, it is better for a visitor, if in doubt, to speak English at the start of a conversation and then adapt his speech if necessary, rather than begin in a jargon that may give offence.

But even in the more sophisticated areas it is convenient for the visitor to have some knowledge of a few of the common native words,

including greetings, since they have often been adopted into the local English or French vocabulary. (Such words are: *lei*, the flower necklet, in Hawaii; *kava*, the national drink of Tonga; *makatea*, the raised coral reef of the Cook islands; *malanga*, the ceremonial visit, in Samoa.)

For anyone who is going to live for some time on one of the islands, a working knowledge of the native language is desirable. These languages, though very alien to European modes of speech, are not necessarily primitive in structure and in the concepts they express. They are adapted to the local way of life, and more exact descriptions of the environment and of social conditions can often be given through them than through English or pidgin English. Moreover, since the native is used to expressing his finer shades of meaning through his own medium, there is more opportunity of getting his ideas correctly and establishing confidence with him. It is quite common for Europeans to live for many years in the islands without acquiring a native language or feeling the need for being equipped with it, but some knowledge of one adds to the interest of contact with the native people. One of the merits of mission work through the whole of the Pacific has been that the missionaries have learnt and used the native languages freely, and have so been able to act as a bridge between the natives and European civilization.

In learning or attempting to understand native languages in the Pacific it should be remembered that many of the sounds which go to make up the words are of different quality from those used in English. In vowels, for instance, the long sound of *a*, approximately as in the English 'far', is used, but the short *a*, not ordinarily used in English, is also common. Thus in the Polynesian *fatu* (stone) and many similar words, the *a* is sounded rather as the vowel in the English 'but', though with the mouth more widely open and the tongue lying flat. The *o* sound has more lip-rounding than in English and is a pure vowel, not a diphthong. Thus in the Polynesian *to* ('to fall') the vowel approximates more closely to the first one in the English word 'morning' than it does to that in the English 'no' (where it is a diphthong) or the English 'to' (where it is a *u* sound). There is also a series of mixed vowels, of the type of the French *u* and German *ö*, not occurring normally in English, but found in some New Guinea languages. Some of the consonants are pronounced in a manner very similar to that in English, so that there is usually little confusion, but slight differences give them a typically native quality. The *b*, for instance, is a voiced labial, but

is not followed by breathing as in English; this has caused some difficulty in identification and spelling, as in Tongan, where the sound now written *p* was formerly written as *b*. The *t* sound is usually pronounced by natives with the tip of the tongue touching the upper teeth, thus giving it a more truly dental sound than in English, where it is pronounced with the tongue a little further back in the mouth. Sounds such as *ny* (the Spanish ñ), *ng* (as in the English ' sing ') and *ngg* (as in the English ' finger ') are also common, the second one in Polynesian languages and all three in Melanesian and Papuan languages. The last of these, itself a compound sound, is sometimes further compounded with a labial sound to give a consonant which may be written *nggbw* in ordinary letters. Another 'sound' of importance in many Pacific islands languages is the glottal stop or glottal closure; this is formed by a constriction of the glottis, which makes no actual sound but results in a break in the voice. In Polynesian languages this glottal stop often, though not invariably, marks the place where a consonant such as *k* has been dropped. Thus the Tahitian word *ma'i*, meaning sickness or disease, corresponds to the Tikopian *maki*. The glottal stop, though it has often been omitted in reducing the languages to writing (as in Hawaiian and Tahitian), is important and should not be left out. Without it, for instance, the Tahitian word given above and commonly written *mai* can be confused with another word *mai*, which has no glottal stop and means ' hither '.

In every language the pattern of accent, that is the manner in which some syllables are stressed and others left unstressed, is important. So also is the intonation, the manner in which the voice rises and falls in the course of a phrase or sentence. The value of following vernacular usage in these matters is that not only does it make for more correct speech, but it often makes a great difference to the ease with which one is understood. People at home with a language often pay as much attention to the ' lilt ' of a familiar phrase as to the individual words in it, and it is surprising how far the words themselves can be slurred if only the general accent pattern and pattern of intonation are preserved. In English and other European languages meaning is assisted by the use of tones, but rarely depends upon it. (In some cases, however, the tone at the end of a sentence is a distinguishing feature, as in such words as ' he's been out,' which may mean a question, a plain statement or an expostulation, according as the tone is varied.) In nearly all the Pacific islands languages the situation is the same. But in one

Melanesian language, that of Jabêm in New Guinea, a tonal system has been recorded in which, somewhat as with Chinese, each syllable of a word has its own proper tone, and the use of another tone instead may entirely change the meaning. In Jabêm, there are high, low and middle tones; as a general rule the high tone is used with syllables beginning with a voiceless consonant and the low tone with those beginning with a voiced consonant.

Before the Europeans entered the Pacific, there were no systems of native writing in use. (The pictographic 'script' of Easter island seems to have been probably only a set of mnemonic signs used by learned men to help them to remember the main ideas of the legends which they chanted.) With the introduction of writing, problems of orthography arose—that is, problems of representing by written symbols the various sounds of the native speech (many of them being different from the sounds ordinarily met with in European languages). In a scientific phonetic alphabet (of which there are a number of different kinds) the difficulties created are met by adding to the ordinary printer's alphabet, where necessary, a set of new signs, diacritical marks, etc. This ensures that each type of sound has its own appropriate symbol, and that no symbol represents more than one type of sound. In ordinary printing, however, especially with the limitations imposed upon the early missionaries who undertook the reduction of the native languages to writing, this is not possible—quite apart from the need for trained linguists to analyse the sounds correctly. Consequently, ordinary letters of the printed alphabet have been made to do duty as symbols for sounds which they do not represent in English or other European languages, and moreover the systems adopted in different areas of the Pacific have often not been consistent. Thus the letter 'g' has been used to represent the sound rather as in English in one area, and the sound of *ng* in other areas, while in others again it has been used in the italic form to represent the sound *ngg*. Further details of the orthographical problem need not be given here, since they have been discussed in various sections of the regional volumes (vol. II, pp. 234, 526, 610, 688–9; vol. III, pp. 54–5, 149, 324; vol. IV, pp. 155–6). These various orthographical devices mean that anyone learning a native language which has already been reduced to writing must take care to familiarize himself with the particular system of symbols locally in vogue. But on the whole, these systems have been of great value; they have usually provided an adequate 'broad transcription' of the native sounds, giving enough special

symbols to avoid ambiguity, in any particular language, and, so equipped, the natives have been able to read the printed matter without difficulty.

On this basis, a considerable amount of literature in the native languages has been produced in the last hundred years—apart from material in the form of traditions, legends, songs, folk tales, etc., put on record primarily for scientific purposes, and grammars and dictionaries compiled to assist in the study of the languages. This literature is of three main kinds. The first is the great body of translations of the Scriptures or part of the Scriptures into a large number of native languages, accompanied by a diversity of prayer-books, catechisms, hymn-books and other material for religious instruction. In the earlier years these were written by missionaries, but more recently the responsibility of translation or writing has been shared by natives as well. Certain books of more than didactic interest may be placed with this category, as for instance *Pilgrim's Progress*, which has been translated into several Pacific islands languages, including Maori and Aneityum. The second kind of literature consists of official and other publications for secular instruction, and includes proclamations, schoolbooks and leaflets or pamphlets on agricultural or other technical subjects. The third kind of literature consists of publications concerned with supplying information of a more general kind, and includes newspapers and other periodicals issued by governments and missions, and at least one commercial weekly newspaper published in Fijian by a firm in Suva. As yet, however, there is little truly vernacular literature composed by the natives themselves; by far the greater bulk of the material consists of translations.

In many areas, one of the greatest difficulties in communication between peoples and in stimulating the growth of vernacular literature is the multiplicity of languages and dialects. These often differ so much that the speech of people living a few miles apart, or on adjacent islands, is mutually unintelligible. In these circumstances both governments and missions have often resorted to the use of a *lingua franca*, selecting one language or dialect and using it as the basic medium for contact between Europeans and natives, for instruction in the schools and for literature. Thus, in the central Pacific, Tahitian has spread beyond the Society islands to the Tuamotu archipelago and other islands near by. In Fiji, the dialect of Mbau has become the standard Fijian speech. In many islands of the northern New Hebrides and the eastern Solomons, Mota, the

language of one of the small islands in the Banks group, was used by the Melanesian Mission as the *lingua franca* (side by side with pidgin English, the *lingua franca* used by government officials, traders, etc.). In the Western Solomons, the language of Roviana has been so used by the New Zealand Methodist mission. The Australian Methodist mission in south-eastern Papua has taken Dobuan as the standard language, and over a wide area of southern Papua the language adopted has been Motu, from the Port Moresby district, especially in the simplified form of 'police Motu'. The Lutheran mission in the east of the Mandated Territory of New Guinea has adopted Jabêm as the *lingua franca* for the Melanesian-speaking areas it covers, and Kâte for the Papuan-speaking areas. The Kuanua language of Blanche bay has been spread by the efforts of missions and government from the Gazelle peninsula throughout New Britain and much of New Ireland, and even to the goldfields on the mainland of New Guinea.

There are advantages in adopting a native language as a *lingua franca*; it is the vernacular of one group, and other groups often find it fairly simple to pick up the vocabulary of a language which in structure may be very similar to their own. But many Europeans are unwilling to learn any native language, or find it too difficult, and prefer to communicate with natives through the medium of pidgin English. Native peoples themselves, in response to this, and partly for reasons of prestige, often prefer to acquire pidgin English as a second language. Many communications between people of different groups takes place through this medium, especially when they are assembled on a plantation or at a European settlement. Hence, in the Western Pacific at least, pidgin English is an important factor in the general linguistic situation, and merits study.

PIDGIN ENGLISH

Pidgin English, known in parts of the Pacific as *tok boi* ('talk boy') is sometimes regarded as if it were merely broken English, a simple, rather infantile jargon obtained by chopping off the endings of words, and with no rules except those suggested by the fancy of the speaker. This idea is erroneous. It is based upon English, but it has its own rules of grammar and pronunciation, and a proportion of its vocabulary is drawn from non-English sources. Moreover, there are certain recognizable differences between the 'pidgin' of different areas—as, for instance, between that used on the China

coast (which by modifying the word ‘ business ’ into ‘ pidgin ’ has provided the name for all these types of speech), that used in the north of Australia, and those used in New Guinea and the Solomon islands respectively. Pidgin English may then be treated as a language with a number of dialectal variants. Wherever it is spoken, the language must be learned. Even Englishmen do not find it easy to acquire, and a common experience of an English visitor to the Pacific islands is to find himself baffled for means of expression in a tongue in which he feels that he ought to be at home from the beginning.

As a rule pidgin English is learned by natives from one another and by Europeans from natives; moreover, natives are usually quicker at picking it up than Europeans are. One reason for this native aptitude is that in the formation of the language the basic vocabulary has been provided by Europeans, but the grammatical structure into which this vocabulary has been interwoven has been partly furnished, unconsciously, by the native speakers, who have incorporated into it some of their own categories. Comparison of following details with some of the material which has been given earlier will show this. It must be noted, however, that in practically no case is pidgin English the ‘ native ’ language of any individuals. For this and other reasons it tends to lack regularity of pronunciation and grammar to the extent to which they are found among ordinary languages, and phonetically there tend to be differences between pidgin as spoken by natives on the one hand and by Europeans on the other.

One of the difficulties facing the newcomer to pidgin is the unfamiliar pronunciation of what would be to him otherwise common words. Diphthongs tend to be sounded as pure vowels; long vowels tend to become shortened; some single consonantal sounds are modified; and two consonants together tend either to be separated by a vowel, or, if the first consonant is a nasal, to lose the final one. Thus ‘road’, ‘teeth’, ‘axe’, ‘box’, ‘stop’, ‘talk’, ‘hand’, are pronounced rather like *rod* (with the rounded ‘ Scots ’ *o*), *tit*, *aekis*, *bokis*, *sitap*, *tok*, *haen*, and so on. (To render the pronunciation accurately, phonetic symbols would be necessary, but the ordinary English letters used in this account give a fair approximation). On the other hand, pidgin English is much simpler in some respects than English. Nouns are used without inflection, normally with the singular English form, and as a rule only the simplest indicative form of the English verb is used. Sentence style is also fairly simple,

with few conjunctions, though the habit of repeating in a clause or sentence the verbal content of the preceding one for purpose of connection is apt to be puzzling at first.

Though the vocabulary is based on English, a number of these English words have acquired new meanings, often of a generic kind. Thus *meri* (Mary) has become the generic word for woman or female of any kind, in New Guinea and Melanesian pidgin; *haus* (house) stands for almost any kind of establishment. *Gras* (grass) is used for 'hair' as well as 'grass'; *faeshen* (fashion) for any manner or custom; *finis* for the completion of anything, or to indicate past action in general; *kilim* (kill him) for 'strike' as well as 'kill'; and *fela* (fellow) as a general suffix to pronouns and adjectives. In addition, a number of words have been incorporated from other sources—as *raus*, 'get out', 'leave' (from the German *heraus*; used only in New Guinea pidgin); *lavalava*, 'loin cloth' (Solomons); *laplap*, 'loin cloth' (New Guinea); *diwai*, 'tree' (New Guinea), all of which come from various native languages.

A few examples will indicate the general grammar and phrase structure. Part of the 'genius' of the language is its capacity to render new or complex ideas into simple basic categories, often by splitting them up into component features. Thus 'office', 'hospital' and 'bank' are treated as species of buildings with different functions; they are described respectively as *haus pepa* (house paper), *haus sik* (house sick) and *haus mani* (house money). A feast is described as *bigfela kaikai* (a great eating) and a cannibal as *maen i-saevi kaikai maen* (man he savvy eat man). An electric torch or flashlight is rendered as *shutelamp* or *shutlait* (shoot-lamp; shoot-light), lightning as *lait bilong klaud* (light belong cloud), a heliograph signal as *lait bilong glas* (light belong glass), and 'to set fire to' or 'to burn' as *lait-im* (light him). Prepositions are few, and consequently perform much work. The two in most common use are *bilong* (belong) indicating possession or other close relationship, and *long* (or *along*) indicating direction, proximity, purpose, means, etc. For instance, pider-web is *haus bilong spaider*; 'the fruit of the tree' is *pikanini bilong diwai* (literally, 'child of the tree'); 'our father' is *papa bilong mi-fela*; 'to hold in the hand' is *holim long haen*; 'he comes to his village' is *em i-kem antap long ples bilong em* (him he come on top along place belong him); 'I'm very hungry' is *bel bilong mi i-singaut long kaikai* (belly belong me he sing out along food). As in most Pacific islands languages there is no verb 'to be,' nor are

the auxiliaries 'have', 'shall', etc., used. 'To have' or 'to possess' is translated by *gat* (got) or by the preposition *bilong* (belong). Transitive verbs are normally followed by the suffix *–im* (him), and the subject of a verb, when in the third person, is commonly repeated before the verb in the form of the pronoun *i–* (he). Thus, 'he hit my father' is *em i-faitim papa bilong mi.* Completion of action is usually expressed by adding *finis* (finish) to the verbal phrase. Thus, 'when he had gone' is *em i-go finis*; 'my brother is (staying) in the house' is *berata bilong me i-sitap finis long haus.* Sometimes the term is used to express finality. Thus the expression *kilim* is used for 'strike', 'hit', as well as 'kill'; when the last idea is expressed, *finis* is usually added. The following conversation (in Solomon islands pidgin) illustrates this. '*Mi kilim wenfela pikanini nau.*' '*Wanaem? Yu kilim finis?*' '*No more! Mi kilim mekim singaut tasol.*' 'I've just killed (hit) a child.' 'What? You've really killed him?' No! I've hit him and made him cry, that's all.'

Time is expressed by a number of adverbs, among the commonest of which are *nau* (now), indicating present and also used as a conjunction; *bifor* (before) indicating previous time; *bihain* (behind) indicating later or future; and *baembai* (by and by), indicating soon or future. Thus: *bifor mi drim mi kilim wenfela senek; bihain i–kim baek; baembai mi tufela go long bus*—meaning 'previously I dreamed that I killed a snake; later it returned, and soon the two of us went into the bush'. One more common usage that may be noted is that of the suffix *–fela* (fellow), which is added to monosyllabic adjectives, to numerals and to first and second personal pronouns. Thus, 'good' becomes *gudfela*; 'we (you and I)' becomes *yumi tufela*; 'one' becomes *wenfela*; 'this' becomes *disfela*; etc.

Pidgin English is primarily a spoken language, but its wide distribution in the Western Pacific, and its use as a *lingua franca* by natives from many different tribes whose own languages are often of very different types, has led to the production of a small amount of religious literature in it. This includes *A Metodist Him Buk*, printed at Rabaul for use in mission services held for indentured labourers, and various free versions of the Testaments issued by Roman Catholic missionaries in northern New Guinea. Some government proclamations have also been printed in pidgin English. Since the language has not become standardized, the orthography and spelling used in these productions may vary from the method

of representation of sounds in the account of the language given above. As a final sample of the construction of pidgin English, showing also its adaptation to mission work, a part of the third chapter of Genesis (verses 1–3), treating of the deception of Eve by the serpent, is given below. It is taken from *The Small Bible History in Pidgin or Tok Boi.* (*Deo* is the word for 'God'; *marsalai* is 'devil'; *devai* is 'tree'; *tambu* is 'taboo' and *kaikai* is 'eat'.)

> *Marsalai i lukim man i gutpela tumas; nau marsalai i koros long tupela i no laik tupela i gutpela na em i no gut. Em i laik pulim tupela long rot i no gut, baembai tupela i no gut tu. Nau i tanim long sinek, sinek i tok long meri i sipik: "vatpo Deo i tokim jutupela i sipik, jutupela i no kaikai long ologeta pikinini belong devai hia?" meri i sipik; "mitupela i kaikai ologeta pikinini belong devai, tasol vanpela i sitap namel long peles, Deo i mekim tambu mitupela long en, i sipik: 'jutupela i no kaikai, jutupela i no holim long han, no gut jutupela i dai.'"*

In ordinary English orthography, translating the foreign words, this passage would read:

> *Devil he lookhim man he goodfellow too much; now devil he cross along twofellow he no like twofellow he goodfellow and him he no good. Him he like pull him twofellow along road he no good, by and by twofellow he no good too. Now he turn him along snake, snake he talk along mary he speak: 'whatfor God he talkhim you twofellow he speak, you twofellow he no eat along altogether children belong tree here?' Mary he speak: 'me twofellow he eat altogether children belong tree, that's all onefellow he stop middle along place. God he makehim taboo me twofellow along him, he speak: 'you twofellow he no eat, you twofellow no hold him along hand, no good you twofellow he die.'*

It must be remembered that though such a rendering seems strange and possibly amusing to an English person, it does not appear so to a native, who is accustomed to the style.

It must be noted, however, that the general official policy in native education is to promote the use of English, even where pidgin English is the accepted medium of ordinary intercourse. In Papua, as an aid to avoidance of the jargon of pidgin, a monthly periodical in English, *The Papuan Villager*, was published by the administration to provide simple reading matter for the native people who were literate.

BIBLIOGRAPHICAL NOTE

Many references to literature on the peoples of the Pacific will be found in the relevant chapters of the regional volumes of this Handbook. The following note cites only the more general ones, and a few of especial interest dealing with particular subjects. Many important articles, too numerous to mention here, will be found in: *The Journal of the Polynesian Society* (published quarterly by the Polynesian Society, Wellington); *Oceania* (published quarterly by the Australian National Research Council, Sydney); and the *Memoirs*, *Bulletins*, and *Occasional Papers* of the Bernice P. Bishop Museum (published at intervals by the museum, Honolulu). No satisfactory general work on any large scale yet exists on the physical anthropology, languages or cultures of the Pacific islands peoples as a whole. Three useful small monographs covering the region, however, are: J. E. Weckler, Jr., *Polynesians Explorers of the Pacific*; M. W. Stirling, *The Native Peoples of New Guinea*; Herbert W. Krieger, *Island Peoples of the Western Pacific, Micronesia and Melanesia* (*Smithsonian Institution War Background Studies*, nos. 6, 9, 16; Washington, 1943). The most valuable general work covering the social, economic and political conditions of the peoples of the Pacific islands (with useful sections on the non-native groups) is Felix M. Keesing, *The South Seas in the Modern World* (New York, 1941; London, 1942). Useful studies of particular communities include: Andrew W. Lind, *An Island Community* (Chicago, 1938)—deals with the Hawaiian islands; J. W. Coulter, *Fiji, Little India of the Pacific* (Chicago, 1942); Laura Thompson, *Guam and its People: A Study of Culture Change and Colonial Education* (Shanghai, 1941); F. M. Keesing, *Modern Samoa* (London, 1934); S. W. Reed, *The Making of Modern New Guinea* (Philadelphia, 1943).

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Chapter XIII

CULTURE OF THE NATIVE PEOPLES

Local Units and Their Social Significance : Kinship : Leadership and Political Structure : Economic Organization : Native People and the Sea : Native Manufactures : Art : Religion and Magic : Bibliographical Note

This Chapter deals with the culture of the native peoples of the Pacific islands. Culture, in the scientific sense, means not merely the arts and the aesthetic interests of a people, but their whole set of customs and institutions—including the social, political and economic principles on which their community is organized, their types of groups, their ceremonies and ritual, their moral, religious and magical beliefs, their technology and the material objects which they use. In the Pacific islands, as elsewhere, cultural divisions do not necessarily coincide with either linguistic or ethnic divisions—for example, a people speaking a language of Melanesian type may have their closest cultural affinities with peoples speaking languages of Papuan type, and *vice versa*. But the cultures of the Pacific islands peoples are very diverse, and classification of them has proved as yet to be at least as difficult as that of racial types or of languages. Though for convenience Papuan, Melanesian, Polynesian and Micronesian cultures are often spoken of, and certain very broad features can be regarded as characteristic of each, there is much overlap. In the following account, therefore, no attempt is made to establish a clear-cut division between them, but a single brief cultural analysis is made of the main features in the area as a whole. Details of the individual cultures are given in the regional volumes of this Handbook.

In this analysis it is convenient to begin with some of the basic principles of the social and political organization.

LOCAL UNITS AND THEIR SOCIAL SIGNIFICANCE

Throughout the Pacific area the organization of the people is one of comparatively small-scale communities. Especially in the west, these are often of tribal character. Each tribe has its own separate territory, a distinctive name, an autonomous political organization (apart from the authority exercised by a European Power) and, usually, some cultural and linguistic differences from its neighbours. Even

where (as in some parts of Polynesia) this fairly clear-cut tribal organization does not occur, and the people of a whole island or group of islands feel that they have common ties, their general interests are rarely crystallized enough to provide a basis for common action; small groups, based on local associations or kinship or both, are the really effective working units of the social system. In former times there was often warfare between neighbouring groups, despite intermarriage and contact by trade and ceremonial exchange. Even today such conditions obtain in parts of New Guinea.

Villages

The basic local unit, serving as the focus for the economic life and for ordinary social affairs, is normally the village or hamlet. This commonly consists of a group of houses irregularly dotted about in a clearing planted with coconut palms, fruit trees and shade trees, and flowering shrubs. Occasionally the houses are set on piles over the sea (Plates 93, 94). But in some areas, mostly because of mission or government influence, the houses are disposed more regularly along a roadside. In parts of New Guinea, a long communal house with separate fireplaces or compartments for households takes the place of individual dwellings.

A feature of villages in some areas is that they reflect the dominant principles of the social organization. Thus those of the people around the St Joseph river in the Gulf of Papua mostly consist each of a double row of houses facing one another across a broad street, with one or more houses also at each end of the street, which serves as village square and a place for dancing and feasting. Each village usually comprises people of several clans and the members of each have their houses built close together in a block, with a men's club-house near by. When only two clans are represented in the village, the line dividing them usually runs at right angles to the street, and the club-house of each clan stands at the end of the street facing towards the centre. The club-house is a large decorated building, with a proper name of its own, and serves as meeting place, sleeping place, place of reception for visitors, and often as place of display of clan badges and for trophies of the chase. In its building, its upkeep and its decoration it is closely associated with chiefs of the clan, who use it as a medium for the display of their wealth and privileges. Some of the villages in the Trobriand islands, on the other hand, have a roughly circular pattern. There is an outer ring of dwelling houses separated by a village street from an inner

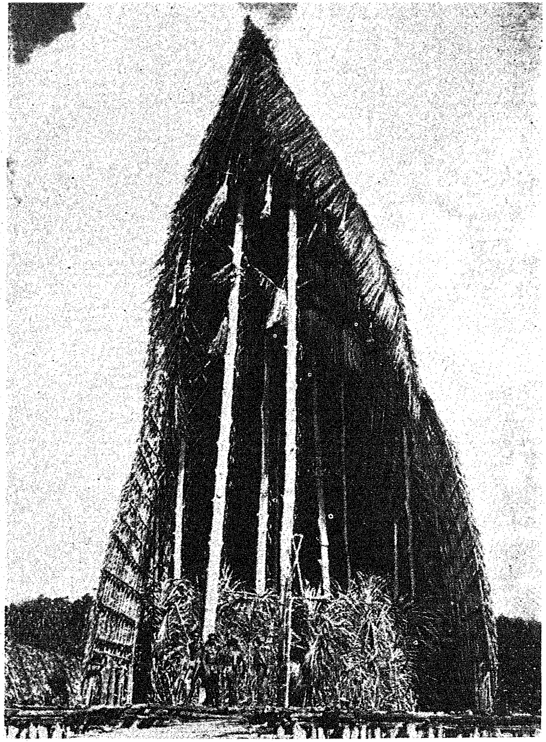


Plate 111. Entrance to the *kau ravi* (men's house) at Kaimari, Papua

This imposing structure is built of mangrove saplings bound together with vines and thatched with sago-palm leaves. It is 70 ft. high at the entrance and is 380 ft. long.

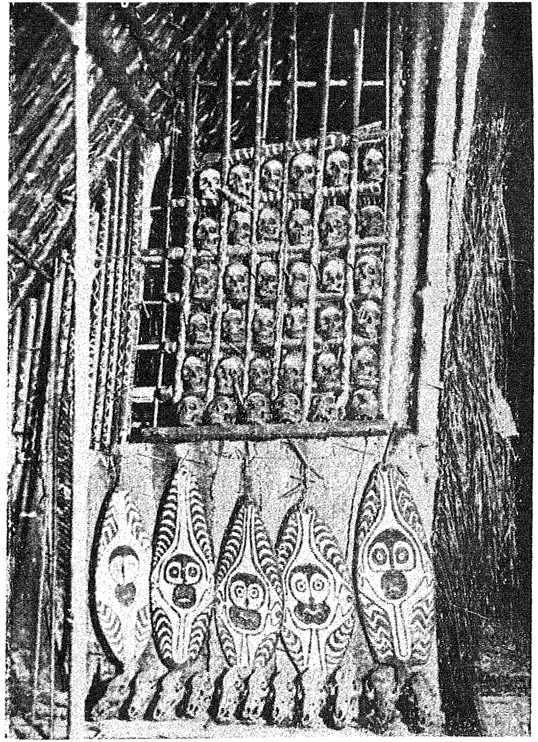


Plate 112. The skull-rack of a chief of the *dubu-daima* of Urama, Papua

Some of the treasured trophies housed in a men's house. The oval plaques with anthropomorphic designs represent the spirit members of the owner's family. The pigs' skulls beneath show the chief's prowess as a hunter.

Plate 113. A Samoan round house

The traditional style of house with thatched roof, large centre post, and many side posts. In this example the floor is raised some distance off the ground, showing that the owners are people of rank.

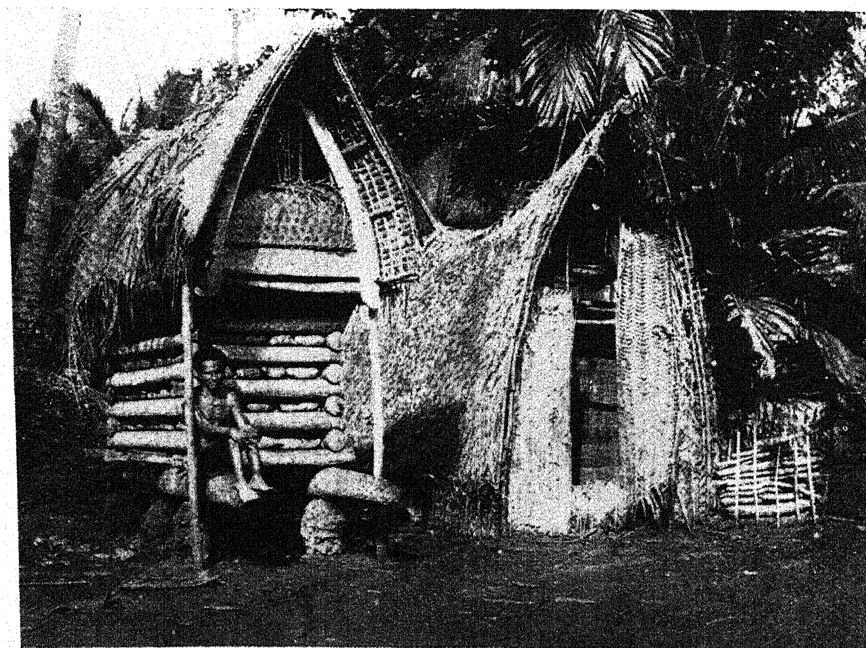


Plate 114. Yam storehouse in the Trobriand islands

The yams can be seen through the open walls of the building. Since success in gardening brings prestige and is measured by the size of the yam crop, more care is spent on the construction and ornamentation of yam stores than of dwellings.

ring of storehouses for yams, which form the staple food of the people. In the centre is an open space, which is the scene of the festivities of the villagers; it has a dancing ground at one end, and in former times part of it was also the village burial ground. If it is a village where a chief lives, his dwelling and his storehouse, larger and more highly ornamented than those of the other villagers, stand in the central space. But in general all the yam storehouses (Plate 114) are better built and more carefully ornamented than the dwelling-houses. They illustrate the very important part which the cultivation, display and storage of yams play in the life of these people, and they are placed facing inwards so that they can be admired from the central space. Residence in the village is not a matter of random selection; the members of each constituent kinship group usually have their houses arranged together in one section. Thus, in a chief's village he and his maternal kinsmen (who are the owners of the village) occupy a section, his wife (or wives) and children occupy another, and other members of the village a third. In other Pacific islands, still different symmetrical village arrangements are found, each representing a social pattern. Again, in many areas, though the houses of a village appear to be casually distributed, their arrangement is determined by hereditary ownership of the land. Each house site is the ancestral property of a kinship group and no one, not even other members of the village, may live there or put up a building there without their express permission. The importance of the village as more than a mere residence is sometimes brought out in another way—by the practice which formerly obtained in parts of New Guinea, and elsewhere too (as in Tikopia, in the Solomons), of burying the dead of the group in the village, in some cases under the dwelling-houses. This practice sprang from various motives, ranging from sentiments of affection to fear of sorcery. But it is one illustration of the ways in which a village acquires traditional and ancestral associations for its people.

Ceremonial Buildings

Details of buildings also may embody features of the social organization. In areas where chieftainship is highly developed a chief's house is usually more elaborately built than other dwellings. Respect for chiefs is shown in some cases, as in Samoa, by giving them higher floors to their houses than commoners have, or, as in the Trobriands, by building tall platforms on to their houses so

that they may sit there during tribal gatherings and so allow the people (who would otherwise have to bend before them) to move about freely. Mention has already been made of the club-houses of the villages around the St Joseph river. Buildings of similar type and function are found in villages throughout many parts of New Guinea—they include the *potuma* of Milne bay, the *koge* of Hood peninsula, the *ravi* of the Purari delta, the *darimo* of Kiwai at the mouth of the Fly river, and a variety of structures known by the pidgin English term of 'house *tamberan*' in the Sepik river region. Some of these buildings are of great size—as much as 120 to 150 ft. long, with a towering front gable 40 to 80 ft. high.

The *ravi* of the Purari delta, which is long and tapering, is supported by two rows of heavy posts, those at the front of the building being 50 ft. or so tall (Plate 111). Great pride is taken in the size of these posts, and a tale is even told of how once visitors to a village shed tears of jealousy when they first set eyes on a new post which their hosts had erected. The interior of the building is divided by screens into a series of alcoves, corresponding to the posts, and each alcove contains a hearth, sleeping mats and other furniture, masks under construction, skulls of crocodile and bush-pig and other trophies, sometimes also human skulls, and a set of carved and painted anthropomorphic slabs (Plate 112). Each of the slabs (which are regarded mainly as decoration though they are vaguely identified with the ancestors) is individually owned and is inherited from father to son. At the back of the building is a closed compartment which shelters a number of large clumsy wickerwork figures vaguely resembling crocodiles. These figures, which are highly secret and may be approached only by properly qualified men, are believed to have magical power, and offerings of food (and in former times, human heads) are made to them. The *ravi* and its accoutrements parallel the social organization of the people. Not only is the building the heart of the village—described by analogy as 'club-house, town hall, market, cathedral and coffee palace'—and associated with a strong group spirit, but also its alcove divisions correspond to the kinship divisions of the local people. Each alcove belongs to a group of kinsfolk with common descent in the male line from some fairly remote ancestor. They are responsible for preparing and setting up the post which marks their alcove, they are the owners of the anthropomorphic slabs which are stored there, and they own one of the wickerwork figures at the back of the house.

In ordinary life the members of such a group tend to act as a

unit. They man a canoe when going off on a hunting expedition, they form their own camp in the bush for tree-cutting and sago-making, and in former times they banded together in fighting to support or avenge any one of their members. In ceremonial life they act in the same way. They consult their own wickerwork figure (which is regarded as embodying a sentient being of mythical origin) as an oracle before hunting, or about the sickness or contemplated journey of one of their members. and they lay the offerings before it. When it decays they ceremoniously construct a new figure and accompany this work by the initiation of sons of their members, or sons of womenfolk of their group, into the secrets and rites of the *ravi*. Moreover, in the *ravi* of different villages, the same names of alcove groups frequently recur; the men of groups with the same name regard each other as relatives, give each other hospitality on visits, and usually refrain from marriage with one another's womenfolk. They hold that they are descended from a common ancestor, and they are further bound together by a mystic link with a particular branch of the multiple delta river-mouth—usually that branch in which is thought to live a fish or other marine creature which acts as the living emblem or 'canoe' of the wickerwork figure. Other sets of groups with different names may also be associated with the river branch, and all the groups concerned thus form a 'river-clan', with in some cases a distinctive style of face-painting at festivals. Another kind of organization is also expressed in terms of the *ravi*. All the men who belong to alcoves on one side of the building constitute a group known as a 'side'. Each of the two 'sides' has its own chief, whose duties are mainly ceremonial, and the members of a 'side' regard themselves as mutually related. They often share the same food, to the exclusion of members of the other 'side'; they do not take wives from their own 'side'; at times they act as a group for feasts. Throughout the area there is a kind of dual division. In general, all one set of corresponding 'sides' of all *ravi* are alined in one group or 'moiety' and all the other set in another. In some parts of the area each moiety has its own style of face-painting, and its own style of carving the roof poles which project from its own side of the front of the *ravi*. One moiety tapers them to a point, the other cuts them into a forked shape resembling an open mouth.

This example has been given in detail to illustrate how intimate and complex can be the relationship between the local environment of a Pacific islands people, their buildings, their social structure

and their religious beliefs and ritual practices. The same theme might be illustrated in many other ways—for instance, by taking the treatment of house-posts in important buildings. In the *darimo* of Kiwai, which is very similar to the *ravi* of the Purari delta, the two rows of posts running the length of the house on either side of a central gangway are carved to represent human figures; magical substances are put at the base of them, and they are endowed with mystic powers and regarded with awe and veneration. Each of the posts is in charge of a clan, and the principal post—that on the right in the centre of the house as one approaches from the door—has special attention paid to it. Not only is it rubbed with various 'medicines' but the male effigy on it is decorated with a feather headdress and painted in red and white to represent a warrior. In former times it was also decorated with human skulls and the eyebrows and lips of an enemy killed in war. The basic purpose of all this is to ward off sickness from the people, and, formerly, to give them success in fighting. In the Melanesian islands the cult of the ceremonial house does not exist to the same extent as in New Guinea. But in the Banks islands and the New Hebrides the *gamal* (*ghamal*, *hamal* and other variants of the name are also found) plays somewhat the same part. This is a club-house or 'lodge' serving the men of the village, in particular those who hold rank in the graded society which is characteristic of this whole area. The main timbers of the building are the centre posts which run in a line supporting the ridge-pole. Custom varies in regard to these posts. In the island of Vao off the north-east coast of Malekula, for example, each centre post has an owner, who is responsible for it and for the sacrifices and food distribution accompanying its erection, when a new building is made. The felling and trimming of the posts and the hauling of them to the building site is a ritual affair, and as each post arrives it is consecrated by the sacrifice of a boar. When the actual building is begun the front post is further consecrated, as representative of the building as a whole, by burying a boar beneath its foot. When all the posts have been set up the workers are ceremonially paid in pigs, mats, yams and other food, and gongs are beaten in celebration of the pigs that have been killed. Here a simple building process is made the focus for a whole set of social and economic activities with a foundation of religious belief. Throughout almost all Polynesia, where the people are now Christian, the old religious associations of buildings have disappeared. But in Samoa, where elaborate large round houses with high thatched

roofs (Plate 113) are built for ceremonial purposes, as for the entertainment of visitors and the formal drinking of kava (vol. II, pp. 611, 617–8) the house posts enter into the social scheme. Those who take part in these gatherings all sit cross-legged on the floor, and the posts provide back rests. Except for a huge centre post, they are arranged in a circle. By tradition, to be seated at a post is a privilege of a man of rank, and the positions are arranged according to definite rules of precedence. One post is that of the high chief, another that of the chief orator, and so on. In Tikopia, a Polynesian community in the Solomon islands, house posts are associated also with the system of rank, and with religion as well. Most dwelling-houses are rectangular and have four or six main posts. The head of the family has his own post as back rest, at the rear of the building. The other posts are used only by male visitors of some importance or by male senior members of the household. In houses which are of some age and in which religious rites take place, one post—that to the rear of the building on the right as one enters—is never used as a back rest. It is sacred to one of the principal ancestors of the family (either he has been buried beside it, or his memorial grave mat is there though his bones lie elsewhere). The post, representing him, is anointed from time to time with oil, and offerings of food and libations of kava are made to him at its foot, in order that he may bring health, a plentiful food supply and prosperity to the family. In the temples of the community, which are larger than ordinary dwelling-houses, the posts, especially the large ones which support the ridge-pole, have an even greater sanctity. They are regarded as representing the gods of the temple and the people, and it is believed that during some important rites a god will descend and actually inhabit his post for a brief space. As his temporary ' body ', it is so sacred that even in ordinary times no one will wantonly lay a hand on the timber.

In many parts of the Pacific islands nowadays, especially in Polynesia, houses are devoid of most of these associations, and villages lack buildings of any special importance except a church and perhaps a trader's store. But in areas which have not been greatly affected by civilization, and even in some which have been exposed to European influence for about a century, such as Samoa, the visitor will find that, simple as the settlements and houses seem, they and their arrangements may embody values which the local people think important, and which should therefore be treated with respect.

Family and Larger Groups

In the preceding section an indication has already been given of the importance of different kinds of kinship groups in the native society. Basic to them all is of course the individual family of father, mother and children. But the family organization is not always of a simple kind. In some societies polygyny (the practice of a man having more than one wife) occurs, especially among men of rank or wealth. This complicates the living arrangements, the inheritance of property, questions of seniority, etc. Again, in some societies, adoption of children is common, with frequent complication of land rights and succession to titles. Among some peoples, domestic relations in families appear to have a strange form, owing to such customs as that of men and women not eating together, or that of the unmarried boys sleeping apart from their families in special houses. In the Trobriands, until recently at least, family life, though appearing to the casual observer to be of normal type, was dictated in many of its aspects by the native theory, held very strongly, that a man plays no part in the conception of children. They are believed to be given to the mother by her ancestral spirits. This denial of physiological paternity has meant that by native custom a man has no rights in his own children. Authority over them and their mother is exercised by her brothers, and it is from its mother's brothers and not from its father that a child receives land, canoes, and other valuable property. (In fact, a father often tries to make valuable gifts to his children, and this is a cause of friction with the legal heirs.)

In Western society we are accustomed to the family, enlarged on occasion by cousins and relatives by marriage, as the only kinship group of importance. In the Pacific islands, however, practically all native societies have larger kinship groups, of a fairly clear-cut kind, which also play important social roles. In Polynesia and in the Papuan cultures of New Guinea, these groups are patrilineal (with descent in the male line). In other societies, as in many parts of Melanesia, they are matrilineal (with descent in the female line). But concentration on one principle of group membership does not mean that kinsfolk on the other side are ignored. In a patrilineal society the mother's relatives, particularly the mother's brother, are usually very important, and in a matrilineal society the father's relatives, especially the father's sister, often have an analogous

Plate 115. Swamp taro in Fiji

In Fiji, as in some other parts of the Pacific, elaborate irrigation systems were formerly used in the cultivation of ' wet ' taro. Nowadays, these have fallen into disuse and only natural swamps are used.

Plate 116. A native garden in the southern Solomon islands

On the extreme left can be seen the broad leaves of a banana plant. In the centre a yam vine is trailing over a stump; behind the right-hand figure is a group of tobacco plants.

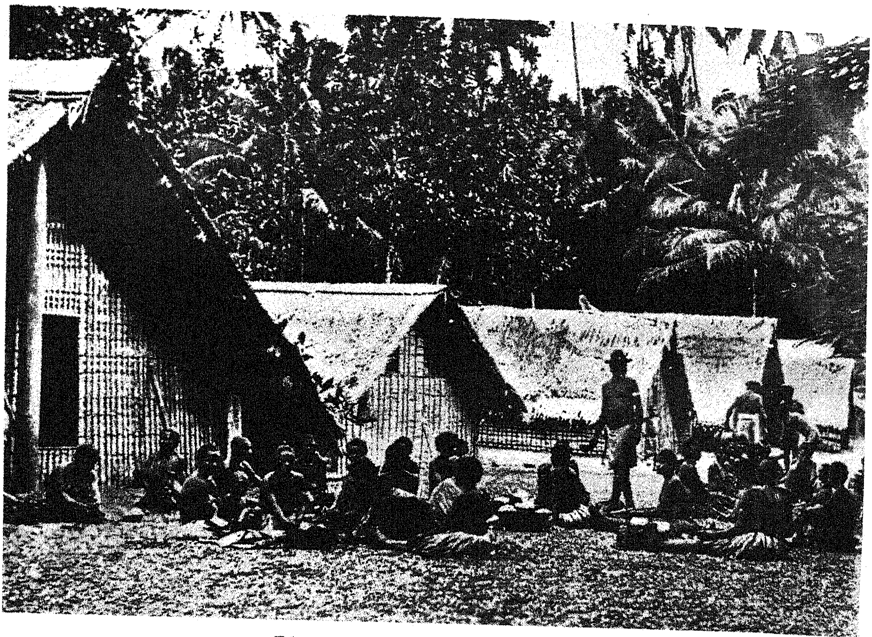


Plate 117. A feast in Malaita
This is one of the feasts given by leaders of the community to the villagers (vol. III, p. 637). Each guest drops a stone into a coconut shell which is carried round; by this means the guests are counted.

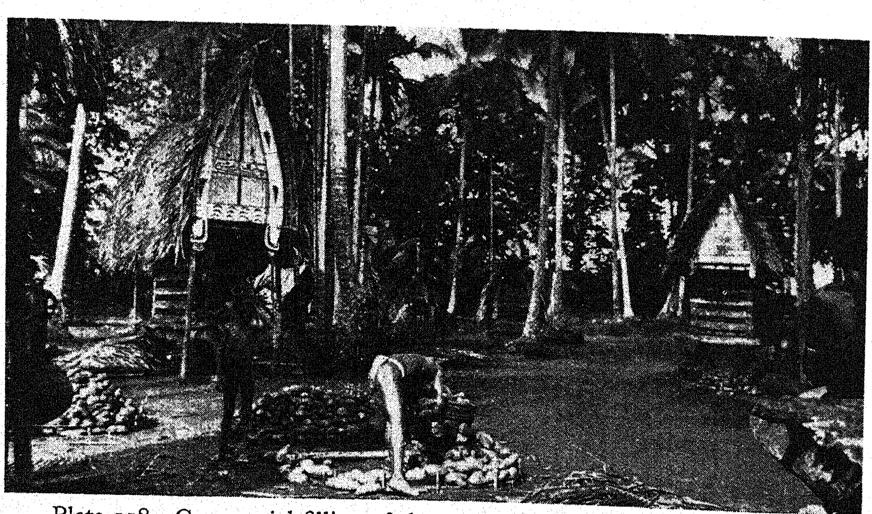


Plate 118. Ceremonial filling of the yam houses in a Trobriands village
Note the decorated boards of the storehouse on the left.

position. When a person is born, is initiated into adult life, is married or dies, it is frequently the members of the groups of that parent from whom formal descent is not traced who take a very prominent part in the ceremonies. Often an integral part of the ceremonies consists in elaborate exchanges of gifts between the kinship groups of the two parents, or in formal payments by the one group to the other for the services they render in taking care of their 'child' at this time. For instance, in Tikopia the kinship groups are patrilineal—a child belongs legally to his father's group, inherits his father's land and other property, and so on. When he is a youth, an operation akin to circumcision is performed upon him, and is made the occasion for great ceremony; it is his formal preparation for manhood. The role of the boy's father and other patrilineal relatives is to accumulate great quantities of food and valued goods such as pandanus leaf mats, bark cloth and coconut sennit cord. The role of the mother's brothers and other matrilineal relatives is to perform the actual operation, hold the boy in their arms during it and generally instruct him and take care of him at this time. The operation itself takes only a few minutes, but the ceremonies cover several days, and the preparations may take months. After the operation, bundles of the property and baskets of the food are presented to the matrilineal relatives—the actual mother's brothers getting the largest share—and they in turn make return presents of coconut sennit cord. In many other ways the mother's brothers look after their sister's children. The result is that at every stage of life a person has the support of both his father's and his mother's group, which have different but complementary functions. This kind of situation, which is very common in Pacific islands communities, even in the most advanced, is at the root of many of the apparently complex ceremonies which the visitor may see, when he is struck by the way in which people seem to be continually coming and going, bringing and taking away food and goods for no clearly discernible reason. (Plate 118 shows the ceremonial display of yams prior to filling a sister's storehouse in the Trobriands.)

In the kinship structure of the different Pacific islands peoples there are many varieties of groups, and even in a single community there may be several kinds—together making up the social fabric. Broadly speaking, however, these groups may be considered as being of two main types, clans and lineages.

The clan organization occurs fairly generally throughout Melanesia and New Guinea, while the lineage organization is most typical of

Polynesia. The clan is a large kinship group, comprising perhaps several hundred members tracing descent from a common male or female ancestor, and is normally exogamous—that is, a person may not marry a member of the same clan but must take his or her spouse from another clan. In some areas, as over most of the west, centre and north of New Guinea, the clans are patrilineal; in others, as in much of south-east New Guinea, New Ireland, and the south-eastern Solomons, they are matrilineal. Frequently, the clans are totemic, each being associated with one or more species of animal, bird, plant, insect, etc., from which the clan often takes its name, and with which each member of the clan regards himself or herself as having a close link of a mystical kind. Sometimes, the members of the clan hold that they are actually descended from the totem—that in the mythical past a snake, pigeon or whatever it may have been, produced human offspring who became the first ancestors of the group—and that they consequently have a tie of relationship with the living totem animals. More often, they do not believe in such totemic descent, but they are usually very averse to killing their totem animal. If it is edible, they do not use it for food, though they have no objection to its being killed and eaten by people of other clans. Occasionally, as among the people of the Morehead river in Papua, it is believed that members of a clan have peculiar powers over their totem, being able by appropriate rites to increase or diminish its supply. Thus men of a clan which takes its name from an aroid plant akin to taro are thought to be able to make the taro crop prosper or to destroy it; if the crop is poor, people from other clans approach them and ask them to take magical action to improve it. A man of the clan taking its name from the mosquito is thought to have the power to bring on a plague of these insects, by piercing a ginger leaf with palm splinters and slapping his body as if he were being bitten. When mosquitoes are especially bad in the neighbourhood, people of other clans may give tobacco or other goods to the 'mosquito' men to alleviate the plague—which they do by various imitative performances.

The lineage organization is usually less rigid than the clan organization in that it is normally non-exogamous—marriage is prohibited between close kinsfolk, such as first cousins, but is quite permissible between other members of the same lineage group. Moreover, it is usually not totemic, though a modified form of totemism occurs in some communities in western Polynesia. In groups of the lineage type great emphasis is laid on common descent from noted ancestors,

and the line of descent or genealogy is remembered with great care. Very often a person can recite the names of his ancestors for anything from twelve to twenty generations back. New lineages are easily formed by splitting or branching off from older lineages. For instance, in process of time the descendants of two brothers will separate, those of the elder forming a senior lineage, and those of the younger a junior lineage. (This process of branching or ramification has led to the use of the term ramage—an old English word—instead of lineage for such groups in Polynesia.)

Both clans and lineages have important social functions. They are often the major land-owning units in the society, and their members often act together as a body in large-scale ceremonies, or in quarrels. Moreover, in virtue of the tie of relationship among them, clansmen or lineage members commonly give one another assistance in economic affairs. But in many areas the clan or lineage is too large a body to meet as a whole for everyday matters, and often it is a non-local group, its members being distributed by marriage or resettlement, or for other reasons, throughout the whole society. Hence sub-clans, sub-lineages or other smaller units with closer local affiliations often exercise more immediate social and economic functions, such as taking direct control of their own lands (subject to the jurisdiction of the larger group), providing working parties, etc.

On the other hand, in some societies, the clans are organized into still larger units. When, as is not infrequently the case, there are only two of these units, thus dividing the community in half, they are known as moieties. In the Morehead district of Papua the various clans or other local patrilineal totemic groups are organized into moieties with names meaning 'front' and 'rear'. People of the same moiety do not marry one another, they often share the same totems, and they share a common set of mythical origins, ceremonies, and ritual secrets, including sacred names for mundane objects. Again, they have traditional associations with certain kinds of plants and other natural phenomena. Thus, the Front moiety is associated with sago and bananas, and the Rear moiety with sugar cane, taro, coconut and tobacco; the sun is believed to belong to the Front moiety and the moon to the Rear moiety. These beliefs, which are backed up by mythical tales, thus provide a loose classification of important natural objects in a way which parallels and reflects the social organization. In New Ireland and some other parts of north-western Melanesia there is a different moiety system, with the names usually taken from birds. Over all New Ireland and the Tabar

islands the moieties, which here are matrilineal, are named Fish-hawk and Sea-eagle. The fish-hawk lives on fish it catches in the shallow reef waters; the sea-eagle also lives largely on fish, and often gets them by chasing the hawk and forcing it to drop its prey. Since the moieties are exogamous, they provide a general structure for the sex life of the people; to have sex relations, either within marriage or outside it, with a member of one's own moiety is the worst crime of the native society. The moieties also act as ceremonial units; their members have reciprocal duties towards one another, often expressed by exchanges of food, on occasions of pregnancy, birth, circumcision, marriage and death. A more complex system of social organization occurs in parts of the New Hebrides, notably Ambrim, where a grouping of the people into three patrilineal clans exists side by side with another grouping of them into two matrilineal moieties. The result is that since every person's position in the society (and, in particular, his marriage) is determined by his membership of his father's clan and his mother's moiety in conjunction, a structure of six groups is formed. These are usually known as 'sections' by anthropologists, but in pidgin English as 'lines'—a term, however, also applied to clans or lineages elsewhere, as in New Guinea. These six-section systems are associated with complicated rules of marriage.

Kinship Terms

In trying to understand the workings of a native society, an important clue is given by the kinship terms the people use. Through all the Pacific islands, what is known as the classificatory system of kinship terms is in vogue. The essential feature of this system is that terms for close relatives such as 'father', 'brother', etc., are extended to include a far wider range of kin than we would include in those categories. Thus not only one's biological father but also his brothers and even his male cousins in the male line are all called 'father'; as a logical sequence from this, one refers to all the children of these 'fathers' as one's 'brothers' and 'sisters'—and so on. This does not mean that there is any actual confusion as to parenthood and relationship; the natives distinguish quite clearly the genealogical position of each relative, and often use supplementary terms such as 'true' or 'real' father or brother, and 'distant' father or brother to make the distinction clear. But this classificatory system of terms does indicate important features of the social system; it is linked with a whole set of patterns of behaviour, including

rights and obligations. For instance, one is expected to show respect towards all one's 'fathers' in various concrete ways, and to help them in work, if called upon; conversely, they are expected to give one protection and hospitality, and to come forward with gifts of food and other property for one's marriage or other ceremonies—in some societies they have to supply the 'bride-price' which is essential before the wedding can take place. On the other hand, the classificatory kinship system usually separates out different kinds of relations whom we normally lump together under a single term. While we use the term 'uncle' indifferently for both father's, brothers and mother's brothers, most of these systems distinguish them; the former are included under the 'father' term, but the latter are called by a separate term, and play quite a different role in the individual's life (as for example in Tikopia, as mentioned above). By classifying all one's kindred into such broad categories, the system thus provides a series of more or less firmly organized groups, each of which has definite functions in regard to the individual concerned. The kinship terms used, and also the kinds of kinsfolk they distinguish, vary considerably in the different Pacific islands societies, and must be studied either on the spot or in the anthropological literature about them. But for anyone who is going to have much to do with native peoples (even those who have had considerable contact with Europeans) is is necessary to be aware of the way in which the natives use their kinship terms, in order to avoid confusion and misunderstanding. To take a simple instance—one gives a native 'boy' a shirt, and then finds a few days later that he has given it away to an old man whom, he says, is his father. One may happen to know it is not his real father, and accuse the boy of lying, not realizing that the old man is his classificatory 'father', and as such has a definite claim upon him—perhaps, among other reasons, because the old man helped to put up the money to get the lad a wife.

LEADERSHIP AND POLITICAL STRUCTURE

Through much of the Pacific, especially in the west and centre, the organization is still essentially of a tribal character, with small units; broad political authority is concentrated in the hands of the governing Power. In parts of the Eastern Pacific, however—e.g., in Hawaii and Tahiti (and also with the Maori of New Zealand)—the native people have been absorbed into the general political structure

(pp. 467–9). A unique situation obtains in Tonga, where a native kingdom has maintained itself under its own ruler and ministers, with a parliamentary system and adult franchise (vol. III, pp. 43, 69–71).

In many parts of the Pacific, especially in Polynesia and in Fiji, an important part is played by the chiefs. In modern conditions they often occupy posts in the system of native administration. In some areas, however, their standing in native society has been ignored and preference has been given to other men whose individual capacity has seemed to offer more promise of efficiency and initiative. One result of this policy has sometimes been to create a rift in the native society, between those who cling to the traditional leaders and those who follow the official nominees. There is usually a close connection between the kinship system of the society and the system of chieftainship. Commonly, the position of a chief rests upon his seniority of descent; he is the latest representative of a line of eldest sons running back to the senior ancestor of the group. Conversely, the people over whom he holds sway are his junior kinsfolk; many of them are older than he, but they are the descendants of the younger brothers of the original ancestor, or of younger brothers of the chiefs in each succeeding generation. This tie of kinship—however remote—between chief and people is one of the most important factors in securing his leadership and in binding the whole group together under him. This theory of male primogeniture—the right of the firstborn son to succeed—is, however, apt to be modified in practice. The right of succession is rarely automatic, but depends on the possession of personal qualities as well. Thus a man of junior status is sometimes elected to the position of highest rank by the people because of his manifestly greater ability than that of the heir by birth. In former times prowess in war sometimes gained a man this position, though some societies drew a clear distinction between war chiefs and chiefs who functioned in other civil and ceremonial affairs. In Samoa, the system of rank dependent upon birth is largely submerged by that of election to titles of chieftainship on other bases such as intelligence, ability in work and in giving advice, and popularity. Kinship, however, still plays an important part, since titles are 'owned' by families, and, other things being equal, seniority in the group is taken into account by the family when it nominates its candidate for confirmation by the council of other title-holders.

The duties of a chief are manifold. He is expected to advise and

lead his people in social, economic and political affairs, to show hospitality to visitors, and to be liberal towards his people in the distribution of food and other goods. Niggardliness in a chief is a major vice. He is often the custodian of the most valued heirlooms and other treasures of the group, the repository of their traditions and ritual secrets, and the trustee or administrator of their lands. He may even be held primarily responsible, as in Tikopia, for the success of their agriculture and their fishing because of the special relation which he is supposed to have to the ancestors and gods of the people. On the other hand, he has certain privileges. He is usually accorded signs of respect—people stand aside from the path when he passes, and may even crouch before him; they speak to him with deference, and go to do his bidding; they may use metaphorical expressions as a kind of 'court phraseology' to describe him and his actions instead of using the ordinary speech. (In the Lau islands of Fiji, for instance, a chief does not 'speak'—he 'makes sound'; he does not have a 'body'—he has an 'ivory skin'; he does not 'die'—he 'falls' or 'sleeps'.) In Polynesia, especially, a chief was and to some extent still is taboo; his body and his personal possessions have a quality of sacredness which sets them apart from ordinary objects and which debars them from being touched or interfered with by ordinary people. Often, a chief alone has the right to own and wear certain types of valued insignia and ornaments. He can call upon his people for work on his house or his canoe, or in his gardens, and he often receives gifts of food and other property, especially on ceremonial occasions. These, however, are not simply tribute without return; the chief reciprocates these gifts and services by feasts and other redistribution of wealth. In former times, and even at the present day in communities which have not adopted Christianity, a chief's position may be demonstrated and to some extent supported by polygyny; his rank and his wealth enable him to become the husband of a number of wives, and they in turn by the marriage gifts they bring, and by their work in his gardens, help to increase his wealth. In most communities with chieftainship, each chief has his definite position in a traditional system of rank, with special functions and privileges accordingly. In Samoa, where the system is highly elaborate, with a comprehensive scheme of chiefly titles, each title has associated with it a certain position in the scale of precedence, a certain seat at the kava ceremony (which is the accompaniment of all public business) and other prerogatives. Furthermore, the titles are of two kinds: those of

titular chiefs (*ali'i*) and those of orator chiefs (*tulafale*, often known to Europeans as 'talking chiefs'). The former have the right to special treatment of their persons and their property; the latter have the right to make formal speeches in council, and to carry a special kind of staff and large fly flap which are the mark of the orator. In broad terms, the division is one between ceremonial and executive leadership; the titular chief has presidential and deliberative functions, while the orator chief carries out the business of the meeting. And in return for the compliments and services which he gives to the titular chief the orator chief receives substantial presents on stated occasions.

In many Pacific islands societies, however, especially in the west, there is no hereditary chieftainship. Leadership is provided by men who have attained their influence by their own personal capacity, as by their ability, their wealth, or by their position in an organization of the graded society or secret society type. Not infrequently a man owes his position to a combination of several of such factors. Among the Iatmul of the Sepik river, for instance, a man achieves standing in the community by his achievements in war, by sorcery and esoteric knowledge, by practice as a spirit medium, by wealth, by intrigue and to some extent by age. This position he maintains and strengthens by conspicuous behaviour in the ceremonial building which serves as a clubhouse for the men; in particular he takes a prominent, often violent, part in the debates which take place in the house. In the New Hebrides and Solomons, on the other hand, a common way for a man to attain power is by the sacrifice of pigs and the disbursement of large quantities of food at feasts (Plate 117). In the New Hebrides, by increasing his outlay (which, however, is recouped in time) he rises through one rank after another in the graded society, which is one of the basic features in the social structure.

Despite the existence of chiefs and other men of rank in many Pacific islands, these communities have usually a basically democratic organization. A chief is not an autocrat. He is elected by his people and is responsible to them for ordering their affairs well. Rarely does a chief take action which he knows to be against the will of his people: he crystallizes, expresses and leads public opinion, but he usually does not try to coerce it. There are many reasons for this, but two important factors are the kinship ties between him and his people, and the intricate economic bonds of reciprocal gifts and services between them. If he acts athwart his people's wishes,

then in addition to their criticism he may find himself deprived of their co-operation. Europeans who have affairs to transact with a native people will find that the chief is a valuable ally, but he cannot be expected to take decisions on matters which affect his people's interests without consulting them or—unless he is a man whose influence is great and whose judgment is respected—to enforce measures which he knows are unpopular with them, particularly if these measures are not part of the customary order. In many of the Western Pacific communities there are no chiefs at all, and the governing force in the groups is a set of important old men, who constitute a kind of informal council. They meet in the men's house, and discuss and decide any questions of importance, while young and middle-aged men listen to them with respectful attention. Even where a village has a native official appointed by the government, he is apt to be guided by the old men in many matters of importance.

The influence of Europeans in the Pacific, however, has brought about many changes in the native political organization, even apart from the transfer of ultimate power and the incorporation of natives in one way or another into the new administrative system (p. 468). The effect of conversion of a people to Christianity, for example, has often been to give the native teacher or other church dignitary considerable political power, sometimes rivalling that of the chiefs; for a time indeed, in some of the islands the government has been practically of a theocratic order. The decay of the old sanctions, many of them based on religious and magical beliefs, has tended to loosen the bonds between chiefs and their people. The opening up of new economic and social opportunities by education, commercial markets for crops and for labour, money and avenues for spending it, has reacted on the native political structure in two ways. On the one hand it has allowed some chiefs to free themselves from their traditional obligations towards their people and to increase their wealth and power by getting control of what were originally group resources into their own hands. On the other hand, it has resulted in a general break-down of authority. The young men in particular have tended to assert themselves against the chiefs and elders as a consequence of their knowledge of European ways gained at school or while working as labourers, and of their command of money. Such tendencies are apt to be especially prominent in the urban areas and around the ports. Something of a counter-reaction, however, occurs at times; systems of leadership are re-constituted

on a newer basis of education and economic ability, and these may be blended with the older system in the person of a young vigorous modern-minded chief. Moreover, in their growing realization of the disintegrative effects of civilization, the people of some islands have tended to attach a sentimental value to their ancient institutions and to preserve at least the outline of their system of chieftainship, with the titles and honours that go with it.

ECONOMIC ORGANIZATION

The economic life of the people of the Pacific islands is organized essentially for getting a living directly from the land and the sea. It corresponds broadly to the peasant economy of Europe, with comparatively small producing units, little secondary industry, and a strong attachment to the soil. Much production is still for subsistence and local exchange. Exports crops, though important in many areas for the provision of cash for the purchase of a small range of foreign goods and for the payment of taxes and church contributions, do not form the main object of economic activity. Many of the adult men engage themselves as plantation labourers or for other service with Europeans. But they rarely seek to form permanent labouring communities and to divorce themselves from their village life. In varying degree, the people have adopted some of the simpler elements of Western technology—for instance, steel tools—but their economic incentives and ideals, as their attitudes to work and to property, are still largely dictated by, and expressed in, the terms of their own cultural requirements. This does not mean that they are simply incapable of appreciating Western economic concepts ; they often consciously prefer their own ways because these seem to them better fitted to secure benefit to all individuals in the community. For example, a European in the Pacific islands is often struck by the way in which a native seems incapable of retaining for himself the products of his industry—if he is a plantation labourer returned home, in a short time his money and the trade goods he has bought are distributed round the village ; if he is an energetic agriculturist, much of his crops and many of his pigs are consumed in a feast to his friends, neighbours and kinsfolk from other villages. This is not just thriftlessness or waste, as it is often imagined to be. The money, the trade goods, the yams, the pigs, go partly to satisfy the wants of other people in the community and form items in the constant interchange of gifts and services by which the community

life is carried on (Plate 118). In part they are payment for gifts and services already rendered to the man concerned in the past, and in part they establish for him a body of credits on which he can draw when he wants material help and other kinds of assistance from the people who have now become his debtors. Linked with this is the general absence of bank accounts, even in areas where the monetary system has become well established. Money obtained is dispersed through kinship and other channels, and if money is wanted, it is sought through these channels. As a Samoan put it, his kinsmen are his bank. This point is epitomized from another angle by the attitude of a Solomon islander who refused to believe that in a Western society people could go hungry or need clothes when there were food and clothing on display in shops. He pointed out that in his community the rules of hospitality and the obligations of kinship could not allow this to happen—if a person is hungry, one *gives* food to him, and if he needs clothing, that is given too. The high degree of economic individualism now so characteristic of Western societies seems repugnant to many Pacific islanders. At the same time, more individualistic concepts are now becoming current, especially near the urban areas, and one of the problems of government policy is how to utilize this growing individualism to provide initiative and enterprise without losing the basic values of the native co-operative system.

Work

In the technical utilization of their resources, and in the economic management of them, the native people usually show considerable skill, though their activities are ordinarily on a small scale. In their agriculture, for instance, they grow a variety of crops (Plates 115, 116). They have a good knowledge of soils and the conditions that favour plant growth, though they express this in empirical rules and not in any very theoretical way. They adapt their methods to each type of crop, planting yams in hillocks to allow of drainage, mulching or trenching taro to conserve moisture, shifting or rotating crops to obviate soil exhaustion. Though many are careless about soil erosion, others often minimize it by terracing and selective weeding. They integrate their agricultural processes carefully with the seasonal cycle, often using the stars, change of winds, flowering plants, or the movements of migrant birds as advance indicators. They often use elaborate religious or magical ritual to promote the growth of crops and stimulate a good harvest, but this ritual is not a substitute

for work and technical knowledge ; it is rather an attempt to meet the deficiencies in their knowledge, to step in where human effort cannot reach—to ward off drought and flood, to block the ravages of pests, to enlist on the side of the cultivator all those elements which we would call good fortune. While modern agricultural science can offer much improvement in technical methods, one difficulty is to adapt it to the needs of the small cultivator, with his limited resources ; and agricultural training, valuable as it has been to the comparatively few who have received it, has still to be matched more closely with economic opportunity.

Hunting and trapping do not play such an important part in the native economic life as do gardening and fishing. On occasions, however, and especially in the larger islands of the Western Pacific, hunting and the snaring of birds play some part. In the Solomons,

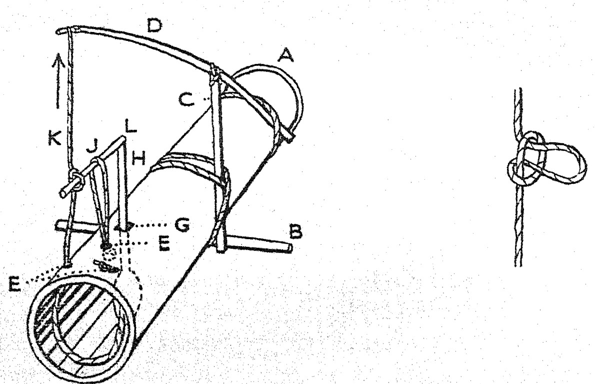


Fig. 100. Rat trap, Samoa

This trap, which is common in most parts of Oceania, consists of a bamboo tube (A) of about 2 in. diameter, to which is lashed a cross-bar (B) for stability, and a springy piece of wood (D), which is supported by a vertical strut (C). The main bamboo tube is open at one end and closed at the other (A). Bait is placed on the stick (H), which projects through the hole (G). A piece of coconut fibre string (K) is passed through the two holes (E) to form a noose inside the mouth of the bamboo tube, furnished with a slip-knot and tied to the free end of the springy piece of wood (D). A short stick (L) is placed with one end through the knot in the string (K) ; with the other end resting on the stick (H) after passing through the loop (J). The upward pull of D is prevented from drawing tight by L, which is pivoted on the loop (J) and prevented from moving downward by H. The rat on taking the bait passes his head through the loop inside the tube and disturbs H on which L is resting, thus releasing L. This action allows the upward tension exerted by D to draw K tight and catch the rat round the neck. Based on Te Rangi Hiroa (Peter H. Buck), 'Samoan Material Culture', *Bernice P. Bishop Museum Bulletin*, no. 75, p. 524 (Honolulu, 1930).

for instance, bows and arrows are sometimes used, especially arrows with blunt points, intended to stun rather than wound the victim, but in Polynesia the bow and arrow, where they occur, are used only for sport. Traps and snares of various kinds, simply made from local material, are used. Fig. 100 represents a rat trap, constructed from bamboo. The example illustrated is from Samoa, but similar traps with slight local variations are distributed widely through the Pacific islands. Fig. 101 shows a simple pig trap from Samoa.

In the utilization of labour, the Pacific islands native still relies largely on the small kinship or neighbouring group. Individual work is common, but also common is the working group consisting of the members of a family, or of a few kinsfolk, co-operating in the common task, say, gardening or producing sago (Plates 128, 129).

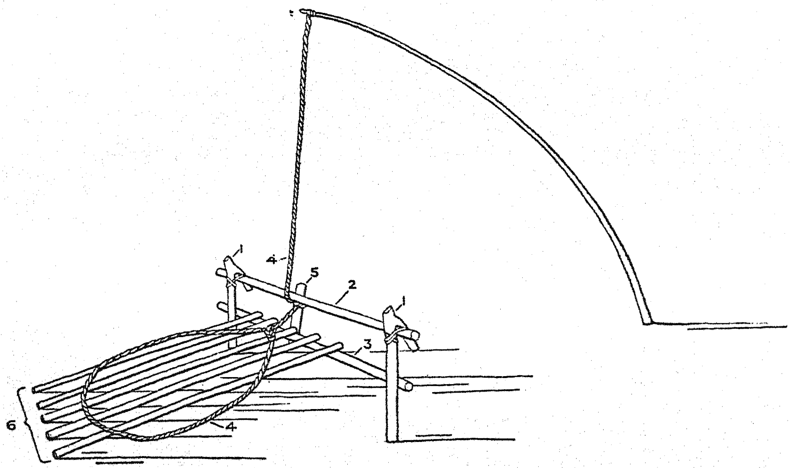


Fig. 101. Pig trap, Samoa

The trap consists of a running noose placed on a framework, with the standing part of the noose attached to a bent sapling. The framework, which is designed to collapse under the weight of the pig, consists of two sticks with knee-shafts (1), between which are placed two transverse bars (2 and 3). The upper bar is kept up against the crooks in 1 by a toggle (5) which is fastened to the standing part of the noose. Pressure from the other end of the toggle keeps the lower transverse stick (3) pressed against 1. Other sticks (6) are laid with one end resting loosely on 3, and also support the noose (4). The weight of the pig on 6 causes them to push 3 down, thus releasing the toggle (5) which flies up, releasing the noose which is drawn tight round the pig by the bent sapling. Based on Te Rangi Hiroa (Peter H. Buck), 'Samoan Material Culture', *Bernice P. Bishop Museum Bulletin*, no. 75, p. 525 (Honolulu, 1930).

For larger enterprises the same principles are applied on a wider scale. For building a new house, for instance, there is an assembly of all the men in the hamlet and kinsmen of the owner from other hamlets nearby. Some dress the timbers, others erect the framework, others cut palm leaves and prepare them as sheets of thatch, and others tie them to the frame in overlapping form. Meanwhile, the women of the hamlet, probably with the help of the house-owner, bring in food from his gardens and those of his kinsfolk, and cook it. When the house is finished a meal is held, thus giving payment to the workers. For fishing, various types of organization are used, but a whole village is often mobilized for a communal fish drive on the reef, with nets and spears; sometimes each fisherman keeps his personal catch, but often the results are pooled for a village feast. In ordinary work there is no high degree of specialization. However, there are commonly some craftsmen who are more skilled than their fellows in wood carving, canoe building, working in shell and turtle shell, and who consequently spend much of their time in such tasks, though they still remain gardeners and fishermen as well. There are usually fewer of such semi-specialists among the women, but some, becoming noted for the fine quality of their bark cloth, their basketry, their mats and their pots, tend to occupy themselves particularly in making these things. Sometimes, because of their natural resources or because of their comparative skill, the men or women of a whole community become noted in a region for their products and become manufacturers for a wide market. Thus the people of the Amphlett islands, who are poor in food resources but skilled in pottery-making, import clay from Fergusson island and export their pots to the Trobriands and other islands, getting in return sago, bananas, yams and coconuts, as well as wooden drums and bowls. The women of Namuka, in the Lau islands, are famed throughout Fiji for their bark cloth. They are organized into a guild under a woman of rank, who receives the orders for exports and regulates the output, and they all use the guild workshop on the edge of the village for those parts of the process needing communal labour. Division of labour between the sexes is normally fairly standardized. In general those tasks requiring greater strength or skill are customarily the work of the men, while those of more monotony are the work of women. Thus, breaking up the ground for agriculture, deep-sea fishing, hunting, house-building and canoe-building are usually men's work; weeding crops, carrying firewood, cooking, care of the house and children, and making of baskets, mats

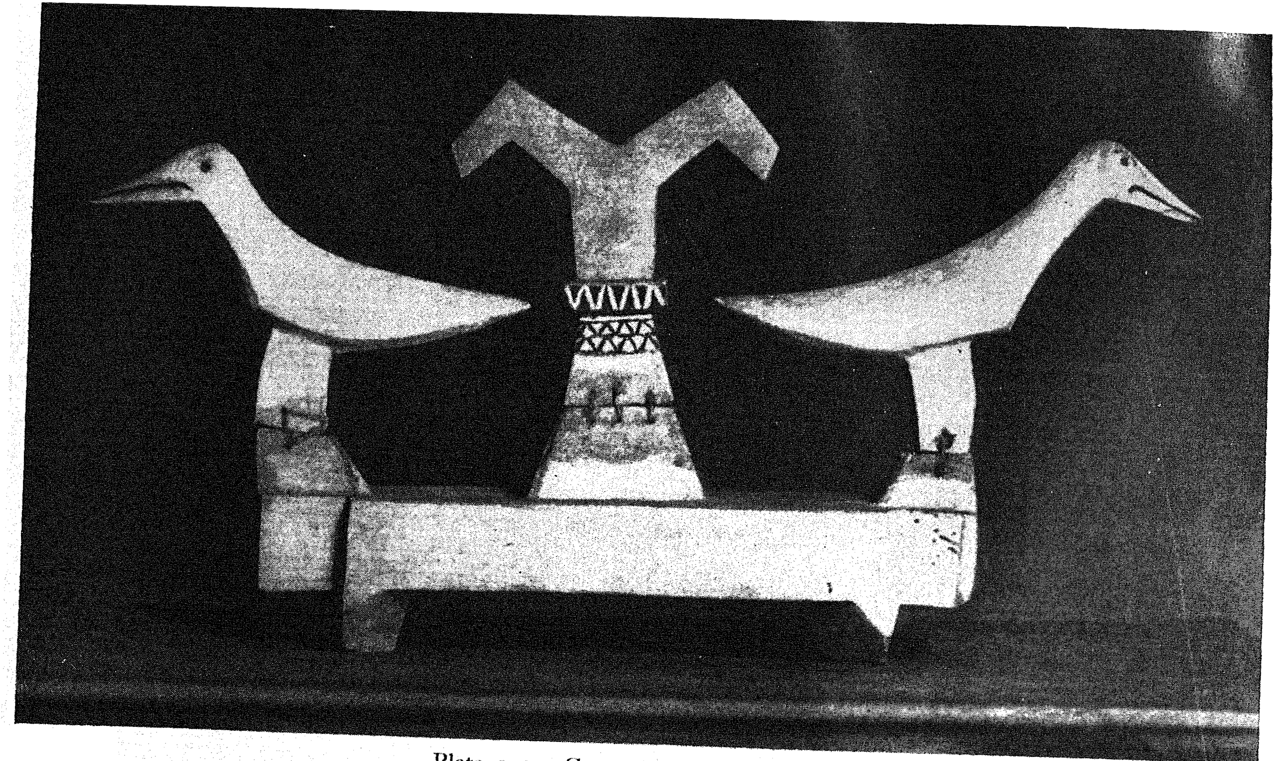
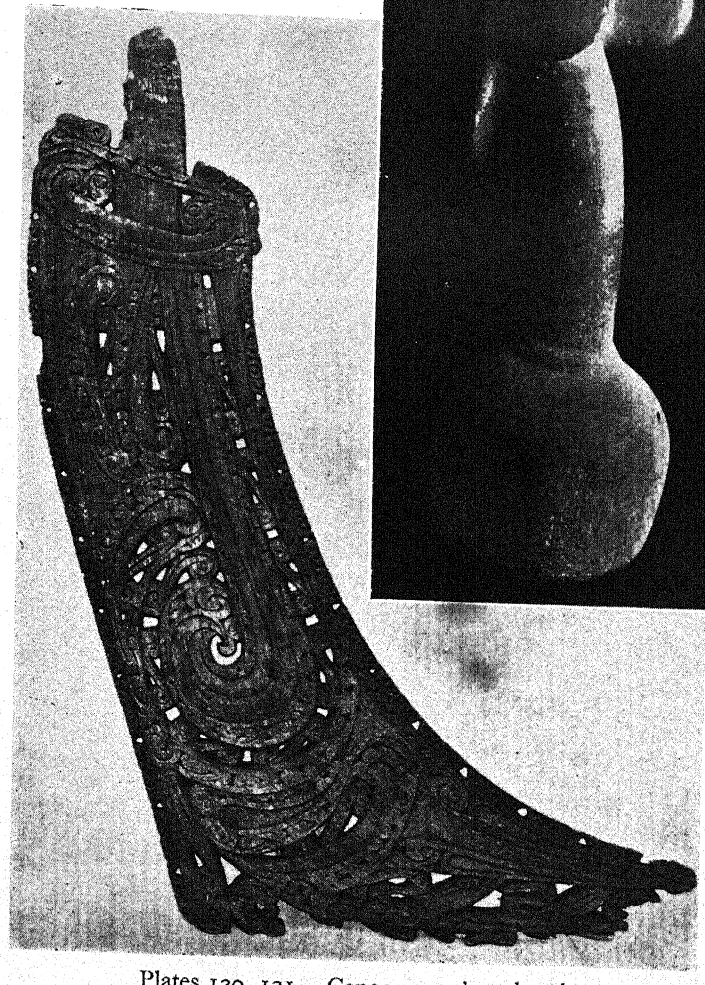
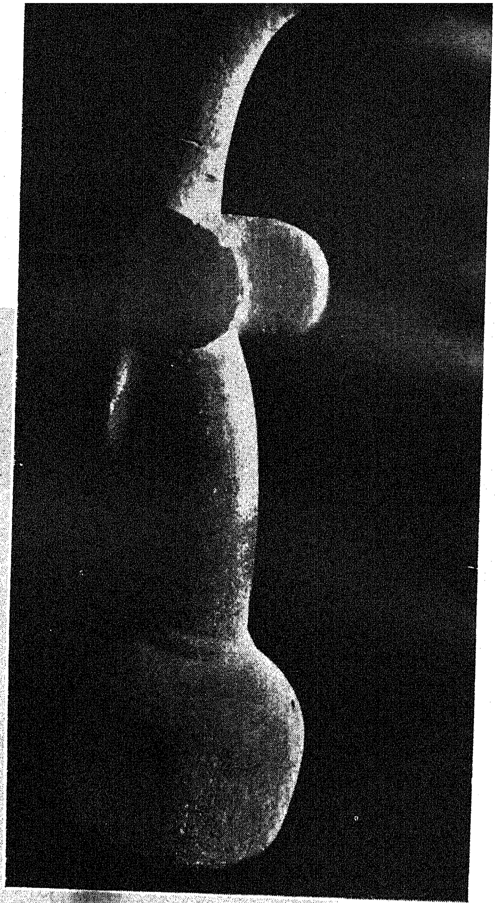


Plate 119. Canoe ornament, Tikopia

The two birds are turnstones, and the central figure is a symbolic animal. These designs are the property of one clan and may not be used on canoes of other clans.





Plates 120, 121. Canoe prow-board and stone pestle
The canoe prow-board (left) is from the Trobriand islands; it is of natural coloured wood, 42 in. high. The pestle (right) is an archaic specimen found in New Guinea by European gold miners.

and pots are usually women's work. But some tasks may be done by either sex, and the line of division is drawn differently in different societies. Whereas in many societies in New Guinea no man will cook, in many others elsewhere both men and women work together at the oven. This sex division of labour is often backed by ritual sanctions.

Property and Tenure of Land

Native concepts of property are often puzzling to Europeans, who, faced by the apparent freedom with which the people use one another's goods, have sometimes spoken of the system as one of communism. This term is misleading. The goods are not simply held in common; there are very definite rights and privileges pertaining to every object, and exercised by individuals in the society. But there is not the same insistence on exclusive individual possession as obtains in Western society. For one thing, borrowing of property is much more common, and as between kinsfolk is a right that may not be refused; if a kinsman is in need of an article, he is entitled to ask for it to be given him. But he is also bound to return either the article given, or an equivalent, at a later date. Often, he anticipates this by bringing a present to the owner of the article he wants, and then making his request. The permanent transfer of property is also managed by a similar process of gift and counter-gift, and in the absence of a money ecomony—or often even where money is now in circulation—this takes the place of an ordinary commercial transaction. Again, while root crops are usually treated as exclusive to the use of the person who has planted them and not to be touched without his permission, tree crops such as coconuts or other fruit may commonly be plucked by members of the kin group of the owner at need, often without asking his leave. Here, however, all depends on the status of the person who takes them; if they are plucked by an unauthorized person this is regarded as theft. Moreover, while small items of property such as a spear, a basket, a fish trap are regarded as belonging to single individuals, certain large and more valuable ones, such as a canoe, may be regarded as the property of a kinship group and held in trust, as it were, by the individuals who actually use them. The general principle is, then, that both individual ownership and group ownership exist, for different types of goods, but that the rights of individuals are always subject to certain conventions of group use according to needs.

The same principle applies essentially to the ownership of land, though here the situation has often been modified by government regulations (pp. 497–9). In native systems of tenure it is rare for any portion of land to be held absolutely by one individual, with exclusive rights of use and disposal. Frequently the land of a community is divided in the first place into a set of large blocks, each of which is the property of a major kinship group such as a clan or lineage. Each block is divided into a number of smaller portions, one or more of which are owned by lesser kinship groups such as sub-clans or sub-lineages. These portions of land are further split up into gardens, house sites, etc., which families or individuals use and hand on to their descendants. Each individual, family or larger group has exclusive rights as against other units of the same type, but these rights are subject in each case to the wider control exercised by the larger corporate body. To take the extreme case, that of alienation of the land—one unit may transfer land to another unit within the larger group, but not to a unit outside this group, unless the permission of the group has been obtained. In many communities the head of the kinship group acts as a kind of trustee of the group lands. His functions include re-allotment of lands that have fallen vacant, as when a family has died out, and general superintendence of the cultivation and other use of the land by the various constituent sub-groups. In the early days of European settlement difficulties sometimes arose because the newcomers regarded the head of the group as the sole owner of the land and thought that his consent alone was needed to enable them to purchase it or occupy it.

But the system described above, though common, is not universal in the Pacific. There are many variations of tenure, and the rules of every community should be inquired into on the spot before land is obtained from natives. In some communities, for instance, where land is plentiful, a distinction is often drawn between land in the vicinity of the village, which is held communally, and land in the bush, which is cleared by individual effort and is the property of the person who has brought it into cultivation. Again, in some communities there is much more emphasis on individual ownership than in others. Thus in the Purari delta, the Kaimari people hold their sago lands, coconut lands and gardens on a communal basis, the administering unit being the *ravi* (men's house), which is equivalent to a village. A man of the *ravi* may fell a sago palm or plant a garden anywhere he pleases within the *ravi* property, and the

produce is regarded as his. When he ceases cultivation there, however, the land reverts once more to the community and anyone else of the group may take it up. Among the neighbouring Koriki people, on the other hand, sago land and gardens are held in individual ownership; every man has several of these in different parts of the village territory, marks them off by boundary signs, and hands them down to his sons, who divide them by mutual arrangement. The people of Nauru, west of the Gilbert islands, have a highly developed form of individual tenure (vol. III, p. 332). House sites, coconut land, pandanus land and fishing pools are all held by individuals, who have exclusive rights of use and disposal of them; neither clans nor hamlets are land-owning units. On the other hand, some communities allow what seem to us to be curious encroachments on the rights of individuals. In Tikopia, for instance, taro gardens are owned and used by families (subject to the rights of larger kinship groups), with the head of each family as effective controller. But when planting time comes any person—member of the owner's kinship group or not—may come and cultivate a plot there, even without asking permission. The crop is his, and may not be disturbed by the owner of the land, though the latter's proprietary rights are recognized at harvest by a gift of a basket of the taro. Again, in many communities, the trees which stand on a piece of land may be the property of quite a different person from the owner of the land. This is so even in Nauru, where the landowner may give the trees to another person, or grant permission for them to be planted on his soil. In such cases, Europeans who have purchased the land have often been confused to find that having paid the price asked for it, they have then been confronted by what seems to them to be an unwarranted demand by someone else for payment for the trees on it.

The inheritance of land is also often complicated. In some communities, land is owned and inherited by men only; in others, both men and women can own and inherit. In many cases inheritance is patrilineal, the land being handed down from father to son; in other cases it is matrilineal, the land passing from a man to his sister's son or from a woman to her daughters. Variants of all these practices may occur. Thus in a community where inheritance is primarily patrilineal, a man's land may pass in the main to his sons, who retain it as common property until their own sons or grandsons grow up, when it is then subdivided. But his daughters may also get some parcels of land as their share of the inheritance. They

use this land, and their sons use it also during their mother's lifetime. But when their mother dies their interest ceases, and the land reverts once more to the patrilineal group.

Systems of Exchange

Though in many parts of the Pacific islands the economy is still largely one of subsistence production, exchange of goods in many forms is important. This is of three main types: (i) ordinary commercial exchange, with money as the medium, when crops, pigs or labour are sold for cash, and food and other goods, mostly imported from foreign countries, are bought; (ii) native trade in goods, without the use of money, as when inland people exchange vegetables against the fish of coastal people; and (iii) ceremonial exchange, both within a community or between one community and another, when valued property changes hands not simply for its immediate utility but as part of the general cementing of group relationships.

Exchange of the first two types is discussed in some detail in chapter XV (pp. 521–1) and little need he said about them here, save to emphasize a few points. With the advent of money there is an increasing tendency for exchange to take place through this medium. On the other hand, there are still some kinds of goods which for sentimental or other reasons are not regarded as being appropriate for monetary transactions. A visitor who wishes to acquire a valued object may find that the owner will not sell it. But though he refuses money, he may be willing to hand over the object as a present, the implied understanding being that some other article of equivalent or rather greater value is given him in return. This convention of gift and counter-gift lies at the root of many native transactions. It secures the exchange, but avoids the purely commercial atmosphere by turning the affair into one of mutual tokens of politeness and esteem. Understanding of this attitude may be of great assistance to a European. It should be noted also that though the hospitality of Pacific island peoples is often generous, the giving of a present usually implies that a present is desired, or at least will be acceptable, in return. The ordinary rules of politeness, aided by the advice of local residents, are normally a good guide in such situations. A great deal of native trade, even when the object is purely utilitarian, is often carried on in such form. Though barter is common, especially in New Guinea, haggling over exchange rates is unusual in the

Pacific; the rates have usually been established by convention, and the parties hand over the articles as if each were making a gift to the other. Often, the exchange of the main objects is accompanied by subsidiary presents as evidence of good will, and here there may be no effort to keep an exact tally and equivalence. Exchange is not confined merely to material objects; immaterial things such as songs and dances are often regarded as personal or clan property and are sometimes traded from one community to another, being paid for in food, ornaments or other articles.

It is often difficult to draw a clear line between commercial exchange and ceremonial exchange, since the former may be embedded in a ceremonial matrix and the latter be accompanied by a series of ordinary barter transactions. But in general the prime motivation of ceremonial exchange is the acquisition of articles not for their ordinary utility, but as part of a process of commemorating some important event, gaining prestige for the participants, or reinforcing ties between individuals or groups. Frequently the objects exchanged between the two parties are identical in kind, or almost so.

Ceremonial exchange between individuals or groups within a community may take place on many occasions, but comes to the fore particularly at times of birth, initiation, marriage and death. The kinsfolk of the person or persons most affected assemble, and as part of the proceedings, quantities of food and other articles are handed over by one group to another; these are repaid either in kind or by equivalent. For example, in northern New Ireland, all boys undergo an initiation ceremony, including circumcision, as part of their introduction to manhood. The ceremony commonly takes place for several boys together, some being of the Eagle moiety and others of the Fish-hawk moiety (p. 409). After the circumcision, an old man of the Eagle group stands up with a bunch of areca nuts from which hang a number of strings of valuable shell discs (commonly known to Europeans as 'currency'). These he presents with a formal speech to the clan relatives of the Fish-hawk boys. Immediately afterwards an old man of the Fish-hawk group stands up with another bunch having attached to it an equal number of shell strings, and presents them formally to the relative of the Eagle boys. Later, there is a distribution of uncooked food, yams, taro and coconuts, contributed mainly by the mothers of all the boys. The food is given to women from other villages, who have come and danced in honour of the boys. But these women had brought taro

with them the day before and cooked it, leaving it as food for their hosts. In many islands of western Polynesia, including Uvea, Tikopia, and even the more sophisticated groups of Tonga and Samoa, an essential element in a marriage ceremony is the presentation of property by the bridegroom's kinsfolk to the bride's kinsfolk, and vice versa; this property is later distributed among the people concerned according to their kinship status. The goods are contributed in a large measure by the immediate families of bride and groom, but other relatives who attend also bring their gifts. In the distribution, the latter receive back more or less an equivalent for what they have brought. In some communities, as in Samoa, the articles presented are of different kinds. The bride's kin contribute mats, bark cloth, calico, grass skirts, coconut oil, turmeric and other dyes; the groom's kin bring live pigs and fowls, tools, ornaments and European foods. Neither side contributes things which belong to the category of the other: a pig, for instance, can never be a substitute for a mat. In modern conditions, the value of the gifts from the bride's kin has risen in some areas, such as the Manu'a group, above that of those from the groom's kin, and consequently a man has to rely on recouping himself from his son's marriage for the outlay which he has incurred by the marriage of his daughter. In general, in these ceremonial exchanges, while the kinsfolk as a body do not lose, and some even gain by the transaction, the immediate family of the person around whom the exchange takes place is often involved in heavy expenditure of food and other goods. This may be recovered later at ceremonies when other people are principals. But the effort to accumulate the large stocks of property required in such transactions is one of the basic motives in much economic activity and planning in native communities.

The close connection between the ceremonial life of the natives and the work they do for a living is shown also by the ceremonial exchanges between different communities. There are many examples of this from New Guinea, as in the exchange of pigs in the *soi* festival of the south coast, where long journeys are undertaken by men for this purpose, or in the exchange of shell armlets and necklaces in the *kula* of the northern Massim area, where elaborate canoe expeditions take place, accompanied by magic and other ritual (vol. IV, p. 172). In both cases the energies of the people engaged may be directed for months ahead towards building up the requisite stocks of goods whereby they can demonstrate their wealth and prestige by giving or receiving on the appropriate occasions.

of the features of such ceremonial exchange is that it commonly involves an elaborate system of credit. In the *kula*, for instance, the armshells and necklaces circulate round the island groups in opposite directions, the latter travelling clockwise, the former anti-clockwise. The people of Dobu, for instance, go north to the Trobriands, carrying no shell ornaments, but merely presents of sago and face paint, which are in quite a different category. They receive from their hosts the prized armshells and return home. Months later the Trobriand men come south, with gifts of carved wooden bowls, lime gourds, etc., and then they receive the shell necklaces, of equivalent value to the armshells they have given earlier. On the whole, fair dealing prevails. A man's position and influence in his community is estimated by the size and number of these shell valuables which he holds and circulates in the *kula* system, and if he cheats his credit tends to diminish and he loses the partners on whom he must rely for his exchanges.

Many kinds of valuable objects are used in these ceremonial exchanges, both within a community and with other communities. They include pandanus mats, bark cloth, wooden bowls, and coconut sennit in western Polynesia; pigs, yams, shell ornaments and wooden carvings in Melanesia and New Guinea. Some of these are employed in so many kinds of transactions that they have been described by Europeans as 'currency', and the strings of shell discs in particular are often called 'shell money'. These shell strings, which often have a regular rate of exchange in terms of European money, do sometimes have a true monetary function, being used as media of exchange and measures of value for other articles. But in many instances—as with the *kula* ornaments—they cannot be exchanged against ordinary objects. For example, in many communities they would never be given in exchange for food. The terms 'currency' and 'money' then, can be properly applied to them only to a limited extent.

NATIVE PEOPLE AND THE SEA

The culture of the Pacific islands peoples has so far been considered mainly in relation to the land. But for many of them the sea is almost equally important. It is true that the 'bushmen' of the larger islands are often afraid of the sea, making poor sailors and worse canoemen. But the people of the coasts and especially those of the smaller islands and atolls, are usually at home on the sea.

They draw much of their food supply from it; they are often good sailors; many of them, like their ancestors, are renowned for their long voyages in frail craft; and the sea enters into a great many of their songs, stories and myths.

Sea Lore

The sea is a constant influence in the lives of the folk of many of the smaller islands. So much is this so, that even ordinary directions may be given by reference to it. In Tikopia, for instance, 'seawards' and 'landwards' are the common directional terms. A man may say 'Pass me the axe—it's on the landward side of the house', or even 'There's a spot of mud on your seaward cheek'. Such islanders have an intimate knowledge of winds and weather and also a fair knowledge of the stars and planets, which they use as indicators of seasonal change and as aids to navigation. This practical astronomy was formerly developed to a high degree by the people of the Gilbert islands, who conceptualized the night sky as a 'Roof of Voyaging' and divided it into sections by an imaginary set of rafters and purlins (vol. III, p. 328), so constructing a sidereal calendar. As might be expected, the native grouping of stars in constellations does not always coincide with ours; the Pleiades, Orion's Belt, the Southern Cross, are among the units which they usually identify as we do, but they aline others differently —the Kiwai people, for instance, treat Capella, Sirius and Canopus as one constellation. Though natives on European vessels quickly learn to steer by the compass, among themselves they naturally have no compass-points. Instead, they use the directions from which the main winds blow. Europeans, without thinking, sometimes translate the native terms as if they were actual points of the compass, which can be misleading since the native wind points are less precise. The maritime peoples, with their keen interest in fishing, usually have a good knowledge of the reefs and sea floor around their island; they know all the depths, patches, shoals and channels. But this sea lore is by no means equally distributed. Some men are comparatively ignorant and follow the lead of others, while some are specialists; in western Polynesia, a skilled seaman is held in high repute, and a term of distinction, *tautai* (sea 'expert'), may be applied to him.

Many of the Pacific island peoples are noted for their sea-voyaging. The Motu of the Papuan gulf, the Manus of the Admiralty islands,

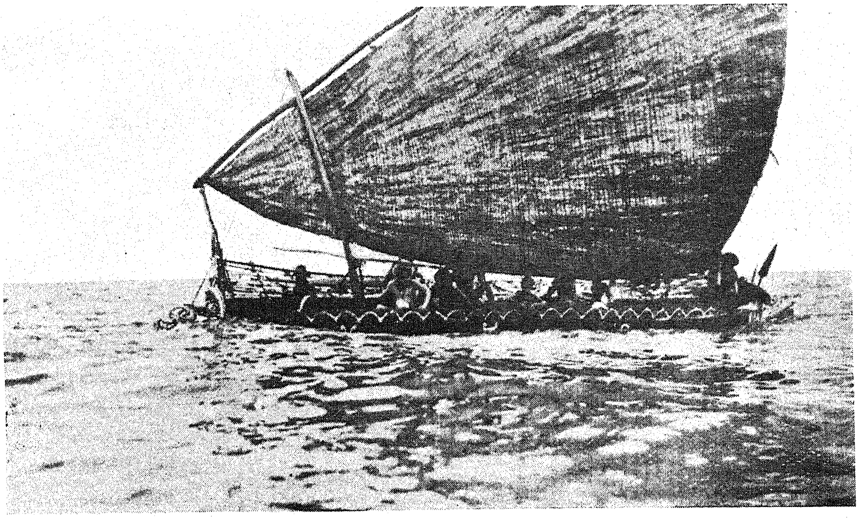


Plate 122. A Trobriands canoe under sail

These large sea-going canoes are used on overseas expeditions to the islands east and south of the Trobriand archipelago.

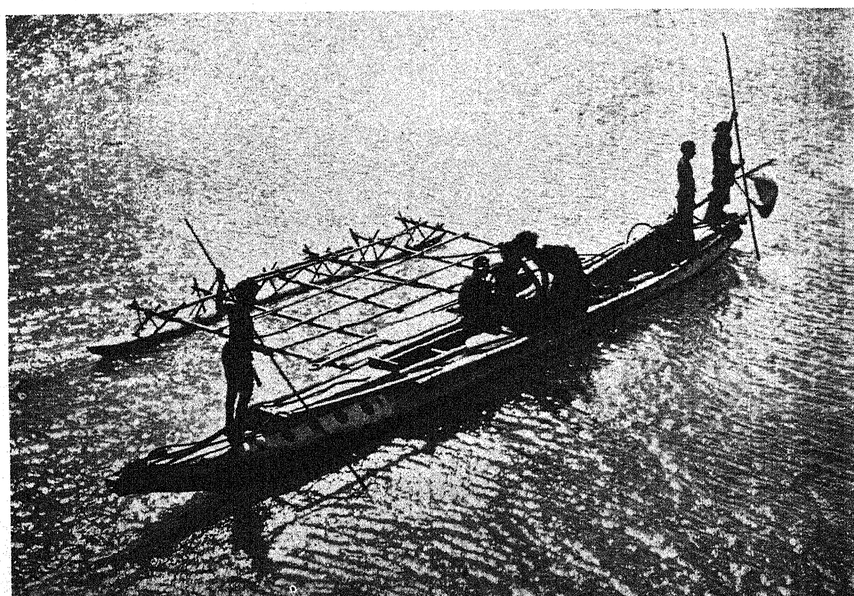


Plate 123. Outrigger canoe of the Motu people, Papua

These canoes are used for fishing and for communication between the pile dwellings (see Plates 95, 96) in which the people live.

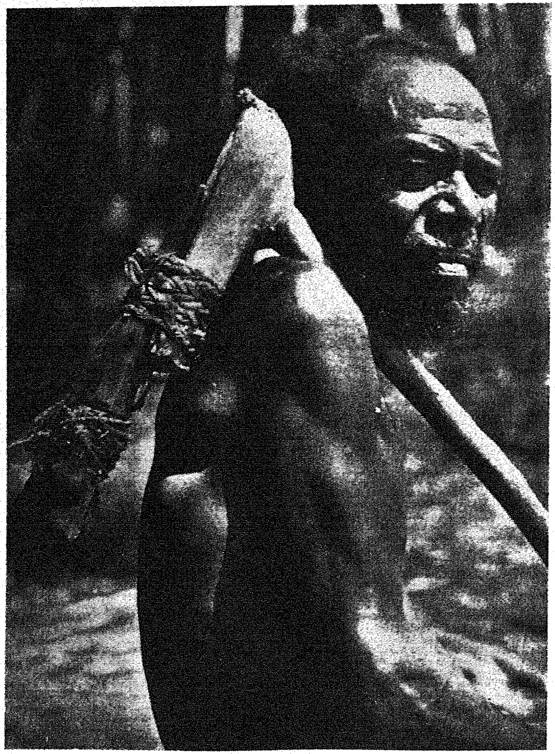


Plate 124. A Papuan with his stone axe
The polished stone blade of the axe is lashed into a cleft piece of wood which is, in turn, lashed to a knee-shaft of wood; the blade is wedged into the haft more tightly as the axe is used.

Plate 125. A fisherman, south coast of Papua
Papuans are expert in fishing with bow and arrow; a man will stand for hours on a pedestal such as this waiting for fish to appear.

the Tami and Siassi of eastern New Guinea, the Trobrianders, the Fijians, and others make long sailing trips for trade and ceremonial exchange; the Solomon islanders paddle long distances across the open sea in their plank-built canoes; in former times the sailors of Tonga travelled 400 miles across the ocean to Fiji to secure sandalwood, red parakeet feathers and large double sailing craft. The traditions of the Polynesians are rich in tales of the voyages of their ancestors in search of new lands or to visit kinsfolk in distant islands, among the most memorable being the migration of some of the ancestors of the Maori from the Society islands and Rarotonga to New Zealand (p. 377), a distance of nearly 2,000 miles. Few of these long voyages now take place, owing partly to the communication afforded by European vessels, partly through decay of the canoe-building and sailing tradition in many islands, partly to specific prohibitions imposed by government in some groups because of the danger of loss of life. But even nowadays, for one reason or another, quite long voyages are sometimes made, often with inadequate equipment.

In addition to their rational knowledge of the sea, these Oceanic people have also built up a great body of lore about it in terms of their magic, their religion, and their mythology. Hardy seamen as they are, there are dangers of the deep which they feel they cannot master unaided, and which they can explain only in terms of the supernatural. In fishing also they call in the help of the unseen powers to ward off evil and secure success. In olden times (and nowadays still where they have not become Christians) they peopled the sea with gods and spirits who lived in the waves, the currents and the ocean depths; who appeared to men in the form of sharks, whales, giant rays, eels and other sea monsters; who dragged canoes down to disaster or who gave miraculous salvation by guiding lost craft to land; who were responsible for shoals of fish or who brought sharks, bleeding from invisible spear wounds, to the hook of the fishermen. The winds themselves were not just natural phenomena—each had its god who dwelt in 'the eye of the wind' and gave calms or storms ('the man-burying sky', as one native song expresses it) as he wished. Granted this domination of the sea and all that pertained to it by spirit beings, the proper course for man to pursue was to secure their favour by propitiation and right conduct. Hence there were long series of religious invocations and magical formulas, of rites and taboos, which, correctly carried out, could bring a favouring wind, allay a storm, calm the waves,

bring fish to the hook or net, and keep off man-eating sharks. Even the native seaman and fisherman who is a Christian still often preserves the remnants of such beliefs and practices, and supplements his prayers by an occasional invocation to an ancient god, or by some simple traditional ritual observance.

Sociology of the Native Canoe

This whole background—of the place of the sea in native thought and of the supernatural associated with it—is important in considering the role of canoes in native life. Nowadays, with the decay of much of the native culture, and the restriction of craft in many islands to simple fishing canoes, a great deal of their value and of the ritual attached to them has been lost. But, where large sea-going craft are still built and especially where the people have not adopted Christianity, old practices still largely survive, and even Christian natives often keep some of the traditional taboos in building and using canoes.

The canoe is usually a very valuable piece of family property. In Tikopia it is referred to metaphorically as 'the orchard of the commoners' because they, being less rich in lands than are the families of men of rank, have to depend more on their canoes for food. Canoes are often given personal names, and the exploits of famous vessels in which long overseas voyages have been made are celebrated in story and song. A canoe is often referred to in a song by a figurative expression which indicates how much it is prized. Thus it may be called 'a necklet of frangipani blossom', signifying that it is like an ornament to a deep-sea fisherman. Large canoes are often decorated with paint or with cowry shells, sometimes with fringes of leaves or feathers; and some peoples, notably the Massim of New Guinea and the Maori of New Zealand, adorn them with elaborate and beautiful carved stem and stern pieces. Even the bailers of important Maori canoes were highly carved, and they, like the anchors of historic craft, were given personal names. A canoe is often one of the most valued objects of native property that can be given in exchange; and in some communities—such as Tikopia—the destruction of a canoe is one of the means of expressing one's deep grief at the loss of a near relative.

The building of a canoe is an important event. The work is done or superintended by specialist craftsmen, who are highly rewarded, and who often hand down their secrets from father to

son. In olden times, and often nowadays also, the craftsman is regarded as possessing powers of a supernatural order, associated with his adze, which is the main canoe-working tool. Thus on Futuna, which has been Christian for about a century, the work of a craftsman is supposed to confer on a canoe spiritual powers which will bring it luck; if a canoe is unlucky in fishing it may be taken to another craftsman, who will change the lashings and impart to it the virtue of his own 'adze-handle'. It is commonly believed that timber, tools and lashing material are all associated with tutelary spirits, who must be placated at different stages of the construction of the craft for it to be successful. Sometimes each canoe is believed to be under the protection of a specific set of spirit guardians, who have periodic offerings of food and other goods made to them. Linked with these rites are various taboos, one of the commonest being the prohibition on women from entering the enclosure where a canoe is being built, and from going on board a sea-going canoe. In Futuna, again, when the log for building a canoe is hauled out of the forest, no one in the party may adorn his hair with lime, or put turmeric on his face or hair; throughout the work no one is allowed to touch the canoe while eating; and on its first voyage no woman is allowed in the craft. The general function of all such rites and taboos is to impress on the people the importance of the canoe in their lives, and to ensure that it is treated with care.

Structural Features of Canoes

The main principles of canoe construction in the Pacific islands may now be described.

Characteristic Features and Construction

While the large double canoes of the migration period have been replaced by schooners of European design, smaller craft are still built with native technique and materials, and used for fishing, local trading and, in some localities, for sport.

The basis from which all canoes are built in the Pacific is a single tree, dug out originally with shell or stone tools but now with European adzes. Modifications are made to give greater freeboard by lashing long washstrakes along each side and often stiffening them with wooden knees. Sometimes two or even three strakes are used. (The large Hermit islands canoe (Fig. 103) is of this multiple-strake type.) When plank-built canoes are constructed the same general

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shape is usually retained. Such craft alone would be unstable in the extreme, and stability is obtained either by lashing two hulls side by side (as in the case of the double canoes) or by attaching an outrigger, a structure consisting of two or more booms projecting over the side of the hull and supporting a float. Some methods of attaching such outriggers are shown in Figs. 104 and 105. In many cases a light decking is placed over the outrigger booms. Often a small platform is constructed on the other side of the hull, and used either for the carriage of cargo or as a counterpoise to the float. The only notable exceptions to the general design occur in New Zealand where the very large *totara* trees make a beam of about

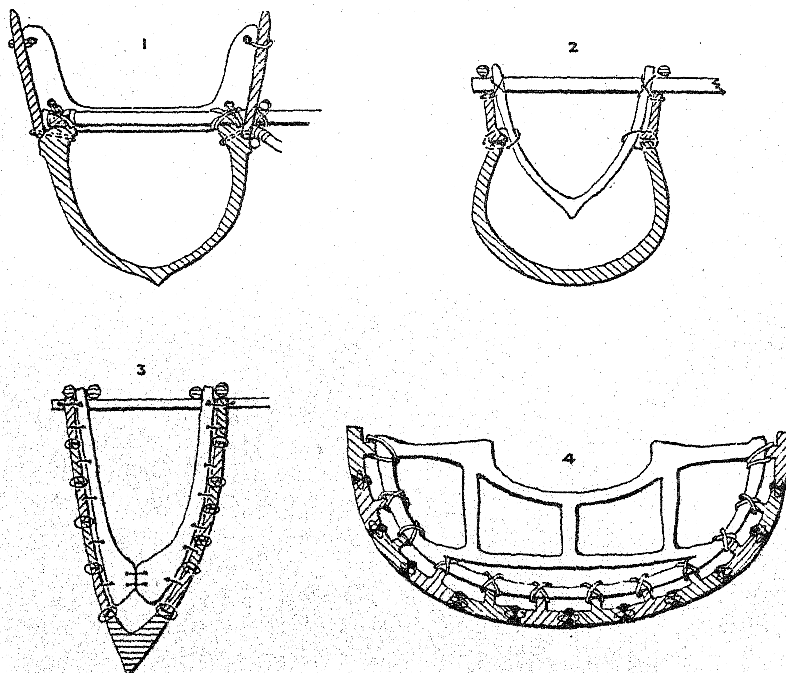
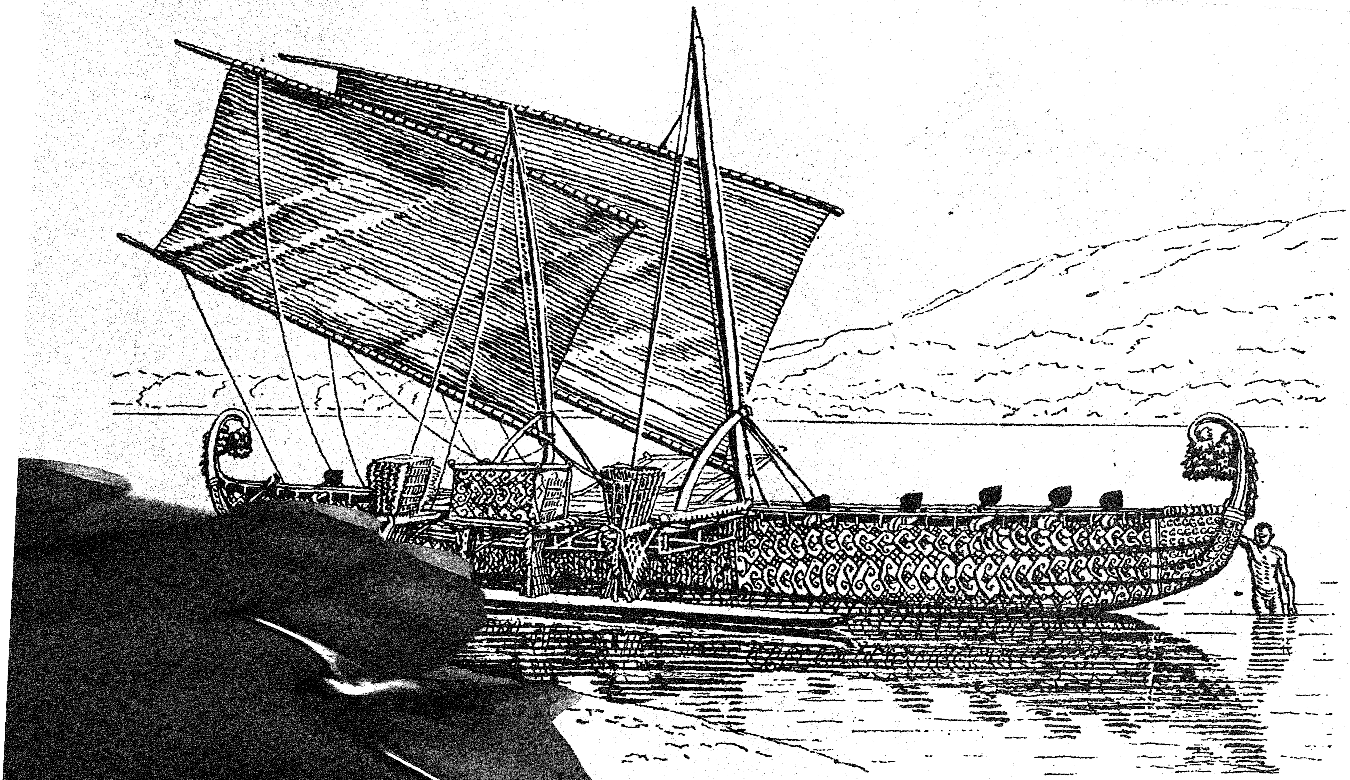


Fig. 102. Cross-sections of canoes

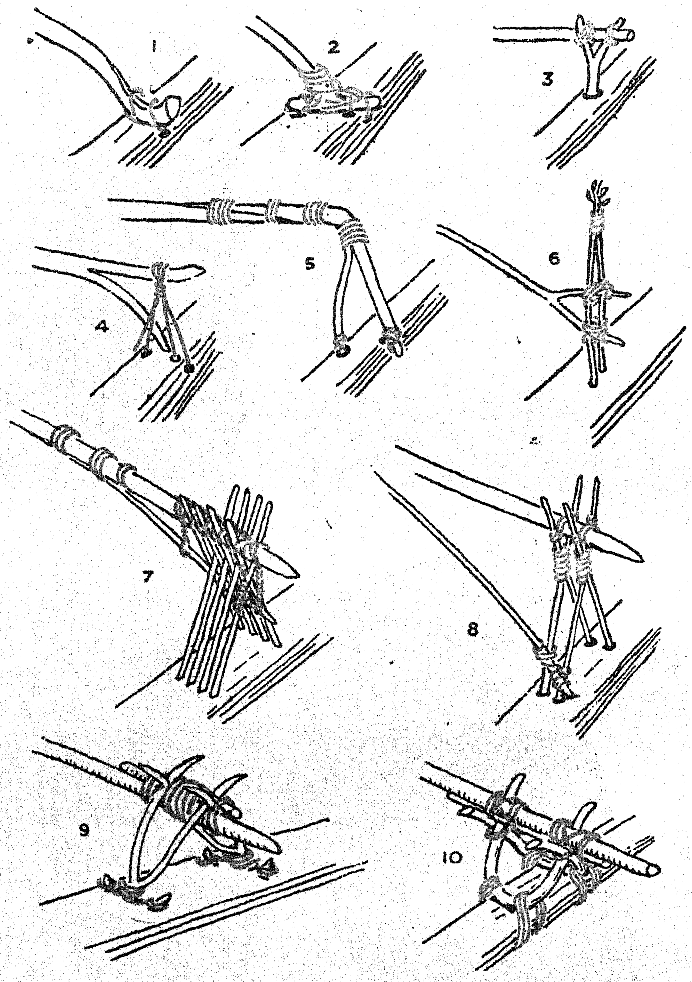
1—single dugout hull with wash-strakes supported by wooden knees (Trobriand islands). 2—single dugout hull with U-shaped wooden frame to support wash-strakes (Niue). 3—plank-built hull of asymmetrical form with inserted wooden frame lashed direct to the planking (Gilbert islands). 4—plank-built canoe with inserted frame lashed to cleats carved on the planks; the planks are sewn together with fibre and caulked with putty-nut gum (Solomon islands). 1–3 are provided with outriggers; 4, with its greater stability, does not need one. Based on the same source as Figs. 104 and 105.

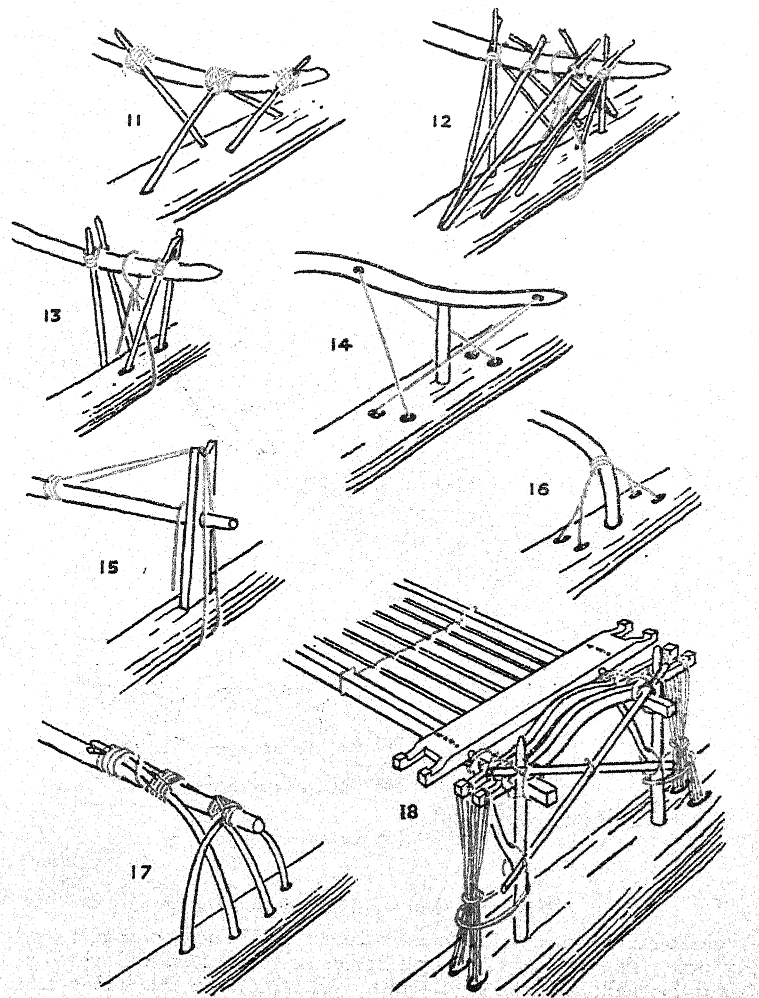


103. Hermit islands canoe

[illegible] dugout hull, with a single outrigger and lee-balancing platform.

[illegible], *Dreissig Jahre in der Sü*[illegible], plate 30, facing p. 464 (Stuttgart, 1907).





Figs. 104 and 105. Examples of outrigger attachments

1, 2, 16—direct attachments: 1, Napuka; 2, Tatakoto; 16, Cook islands (after-boom only). 3—forked-stick attachment, Aitutaki. 4—forked boom reinforced by sennit braces, Mangaia. 5—angular stanchion with flexible subsidiary strut, Reao and Tatakoto. 6—vertical struts attached to forked boom, Gazelle peninsula, New Britain. 7, 8—under-crossed stanchions re-inforced by subsidiary brace: 7, Hermit islands; 8, Trobriand islands. 9—two forked sticks bent together, New Caledonia. 10—two U-shaped connections, north-west New Britain. 11, 13—oblique stanchions with bracing: 11, Fly river, New Guinea; 13, Samoa. 14—vertical stanchion with oblique bracing, Fakarava. 15—plank and bracing (modern), Marquesas. 17—curved stanchions and braces, Rapa. 18—Y-shaped stanchions and rope braces, Palau. The localities mentioned are those from which the examples are taken, but given types of attachment are not necessarily limited in their occurrence to these localities. Based on A. C. Haddon and James Hornell, 'Canoes of Oceania', vols. I and II, *Bernice P. Bishop Museum Special Publications*, nos. 27 and 28 *passim* (Honolulu, 1936, 1937).

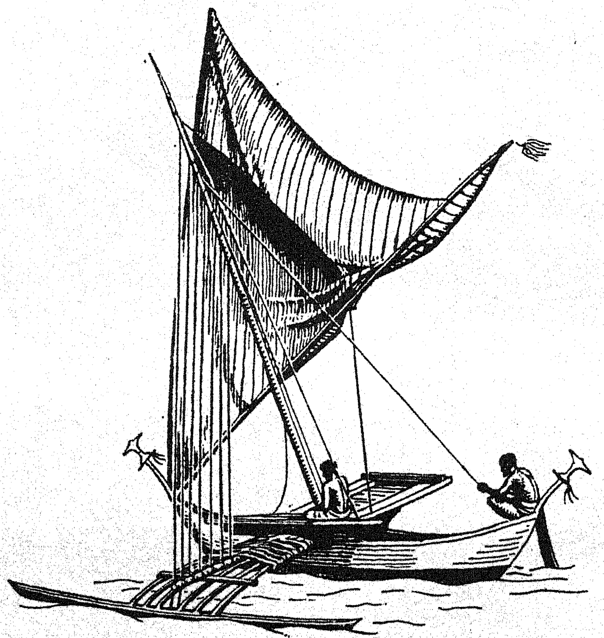


Fig. 106. Marshall islands fishing canoe

A plank-built canoe with Oceanic lateen sail, single outrigger and lee platform. Thc sail is shown being brailed up. Based on A.C. Haddon and James Hornell, 'Canoes of Oceania', vol. 1, *Bernice P. Bishop Museum Special Publication*, no. 27, p. 367 (Honolulu, 1936).

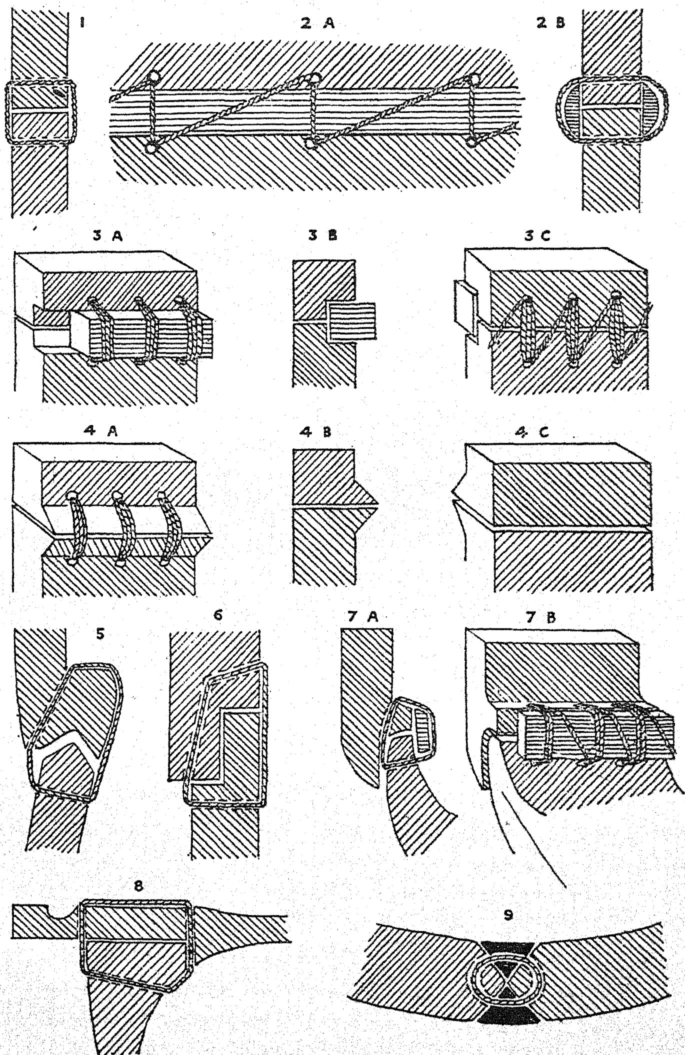


Fig. 107. Methods of lashing planking of canoes

1—Gilbert islands, section. 2—New Zealand: A, inside; B, section. 3—Tongareva: A, outside; B, section; C, inside. 4—Samoa: A, inside; B, section; C, outside. 5—Cook islands, section. 6—Hawaii, section. 7—Manihiki: A, section; B, inside. 8—Palau, section. 9—Solomon islands, section, with caulking of putty-nut gum shown in black. Based on the same source as Figs. 104 and 105.

5 ft. for the dugout part of the hull possible, and in parts of Melanesia, especially in the Solomon islands, where a specialized plank-built canoe with a relatively wide beam has been developed. Long strakes are lashed to the dugout hulls with coconut-fibre lashings, with, in some cases, the upper strakes overlapping them as in European clinker building. In the plank-built craft, planks are set edge to edge in a manner analogous to carvel building and lashed with coconut fibre sennit (Fig. 102). Where frames are used, they are inserted afterwards and lashed to the planking. To reduce leakage, many ingenious methods are devised to keep the lashing of the planks concealed or on the inside of the hull; a common method is to carve flanges along the inner edges of the planks to take the lashing. But in many areas, where canoes are built up like a jigsaw puzzle of odd-shaped planks, the lashing passes right through the planks. Fig. 107 shows methods of lashing planks in various Pacific canoes, and Fig. 108 the lashing of the planks and patches of an Uvea canoe. A layer of bark cloth with breadfruit gum as a cement is a common caulking medium. In the Solomon islands, the gum from the 'putty nut' is used.

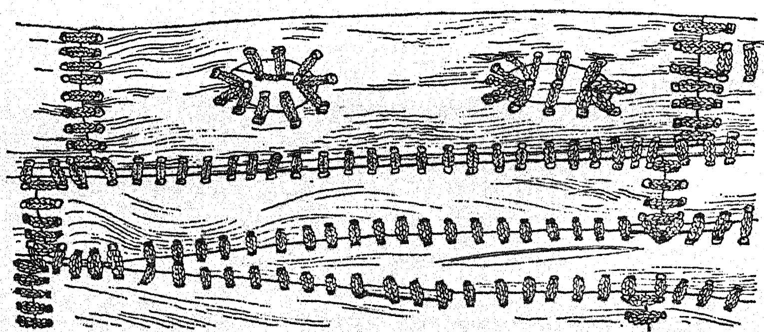


Fig. 108. Side planking of an old Nukutavake canoe

This shows the method of lashing irregularly-shaped planking with coconut-fibre sennit. Note the two patches in the top strake. Based on a photograph.

There are many methods of attaching the float to the outrigger booms. In simple canoes, the boom is often curved down to the float and lashed or spiked to it directly, but in some cases some form of indirect attachment by stanchions and braces is used (Figs. 104—nos. 3–10; 105—nos. 11–15, 17–18). A particularly interesting

arrangement is found in the Society islands, where the main outrigger boom is a substantial timber attached to the float indirectly by stanchions, while the after boom is a thin pliable stick attached directly (Fig. 109). This allows the boom a certain amount of play.

Sails and Rigging

In contrast to primitive European sails, those used in the Pacific are almost without exception fore-and-aft sails (Figs. 103, 109, 111–14), although a primitive temporary square sail is frequently made by plaiting two palm leaves together. Sometimes, just a single palm leaf is used as a sail when running before the wind. The more common sails are a square-shaped sail with yard and boom set like a lug, the spritsail, and two variants of the lateen sail (both differing from the Mediterranean lateen sail in that they have a boom). In the Melanesian variant—sometimes known as the crab-claw sail (Figs. 111, 113)—the yard and boom are very long and curved, and the head of the sail is cut away in a semicircle. The weight of the boom pulling on the head tends to keep the whole sail flat. It is hoisted by a single halyard (which may be duplicated or triplicated for strength) in the middle of the yard. The apex of the sail, which forms the tack, is clewed to the foot of a vertical mast stepped amidships and stayed to various points on the outrigger. A sheet runs aft from the boom, and a guy rope leads forward where it is lashed to prevent gybing. In the Polynesian and Micronesian form (Figs. 106, 112), the sail is more triangular, laced to a straight, or nearly straight, yard and boom. The apex is still the tack, but the free side of the sail is functionally the leech. The mast is stepped amidships and raked forward. It is held in position by shrouds to the outboard end of the outrigger booms and by a crutch. The fore stay and back stay are one continuous running stay to facilitate reversing the rake of the mast (see p. 437). In a more primitive form of this rig, the yard is simply supported on a short Y-shaped crutch.

The Oceanic spritsail consists simply of a triangular, or nearly triangular, sail with two poles which may be termed either mast and boom, or yard and boom. The sail is set apex downwards with the ends of the two poles resting on a thwart. They are usually small and can be easily struck in heavy weather. A larger and more complicated variant of this sail was that formerly used in Hawaii and the Society islands, which was roughly D-shaped, with the luff

of the sail laced to a vertical mast, and the leech to a curved boom. The head of the sail sometimes assumed a crab-claw shape. The material was usually plaited pandanus leaf, or strips of pandanus leaf sewn together. Today European sailcloth is used and canoes are rigged as cutters or sloops, or simply with spritsails.

Methods of Sailing

The handling and sailing of canoes is complicated by the fact that the value of the float as a stabilizer lies principally in its weight, and not in its buoyancy. Consequently it must be kept to windward

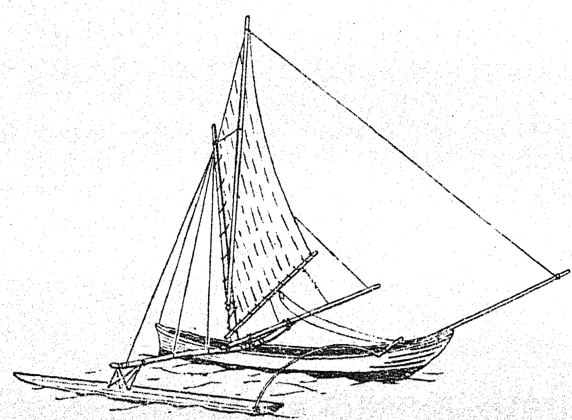


Fig. 109. Modern Society islands fishing canoe

The outrigger float is fixed rigidly to the main outrigger boom, but the after boom is flexible, allowing a certain amount of play. Note the balancing-pole opposite the main outrigger boom. A European spritsail is now used with the traditional hull and outrigger form. Based on A. C. Haddon and James Hornell, 'Canoes of Oceania', vol. 1, *Bernice P. Bishop Museum Special Publication*, no. 27, p. 124 (Honolulu, 1936).

unless special precautions are taken. If the float were to leeward, it would be driven under water and either it would be broken off by the stresses imposed on it, or the canoe would fill and capsize. In some canoes a lee balancing platform—in its simplest form a single spar—is built out opposite the outrigger and members of the crew will sit on this as a form of live ballast. But more usually canoes, even if they possess the balancing platform, are double ended and made reversible, so that the float may be kept to windward. This has its bearing on the rigging. Where the mast is stepped vertically amidships, the reversal of the sail is a simple matter. Canoes

carrying a square-shaped fore-and-aft sail have their halyard in the middle of the yard; and one corner of the sail, functioning as the tack, is clewed to the mast, while the sheet is attached to the other end of the boom. When the canoe goes about, the tack is paid off and becomes the sheet, while the sheet is hauled in and becomes the tack. With the Melanesian crab-claw type of lateen the sheet is paid out till the sail hangs out to leeward and is then hauled in to the other end of the canoe. With the Polynesian or Micronesian type of lateen sail, the canoe is luffed to take off way, the sheet is paid off, and while part of the crew haul on the back-stay to rake the mast aft (i.e., to the new bow), others carry the tack of the sail to the other end of the canoe. The sheet is then hauled

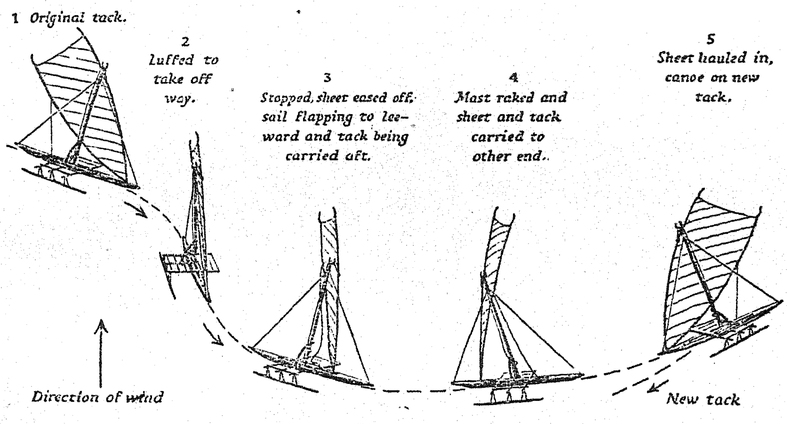


Fig. 110. Method of tacking with a canoe

The sail and mast are reversed in order to keep the outrigger to windward. Based on A. Grimble, 'The Canoes of the Gilbert Islands', *Journal of the Royal Anthropological Institute*, vol. LIV, p. 126 (London, 1924).

in and the canoe starts off on its new tack. (Fig. 110 shows these operations diagramatically.)

Steering is usually performed by a large paddle, but in Micronesia a quarter rudder frequently is used instead. With most types of canoe considerable leeway is made and it is necessary to steer somewhat to windward of the intended course. Micronesian canoes, however, with their deep narrow section (Fig. 102—no. 3) make little leeway. The bow and stern covers fitted to some types of canoe afford some protection against weather, but in any sea they are apt to ship a fair amount of water. This, in addition to

leakage through joints in planking, renders bailing necessary. The bailers carried are of wood and are scoop-shaped with the handle often projecting forward.

Present-day Double Canoes

The only double canoe still in regular use is that found along the south coast of New Guinea, near the island of Mailu, where two simple dugouts up to about 35 ft. long, with single wash-strakes are joined by a square decking. They carry the Melanesian crab-claw sail. They are used as trading vessels. This type of canoe is

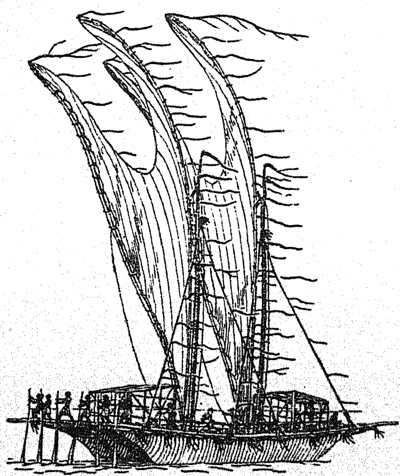


Fig. 111. Lakatoi from south-east New Guinea

This is a large composite craft built up of three or more dugout hulls and used for coastal trading voyages. The deck-houses and bulwarks are generally covered with palm leaves. Stays for the mast lead to one side of the hull only and the craft is reversed when tacking. Note the numerous steering paddles. Based on photographs.

seaworthy, moderately fast, and fairly weatherly. Allied to the Mailu double canoe is the *lakatoi* (Fig. 111) of the Motu people. This is really a raft built up of several dugout canoes lashed together with a deck covering them all and with two masts and crab-claw sails. Long voyages with large quantities of cargo are made by craft of this type, but they are slow and cumbersome and make a lot of leeway.

Single Outrigger Canoes

Perhaps the most specialized and most highly developed single outrigger canoes are found in Micronesia (Fig. 106), where canoes up to 30 ft. long are still in use today. They consist of a long plank-built hull with an extremely narrow beam, a single outrigger float, and a lee balancing platform. The rig is the typical Micronesian lateen with a raking mast.

The keels of these craft are curved laterally with the convex side towards the outrigger. The effect of this is twofold. The curve tends to counteract the pull of the outrigger. The hull is also as a

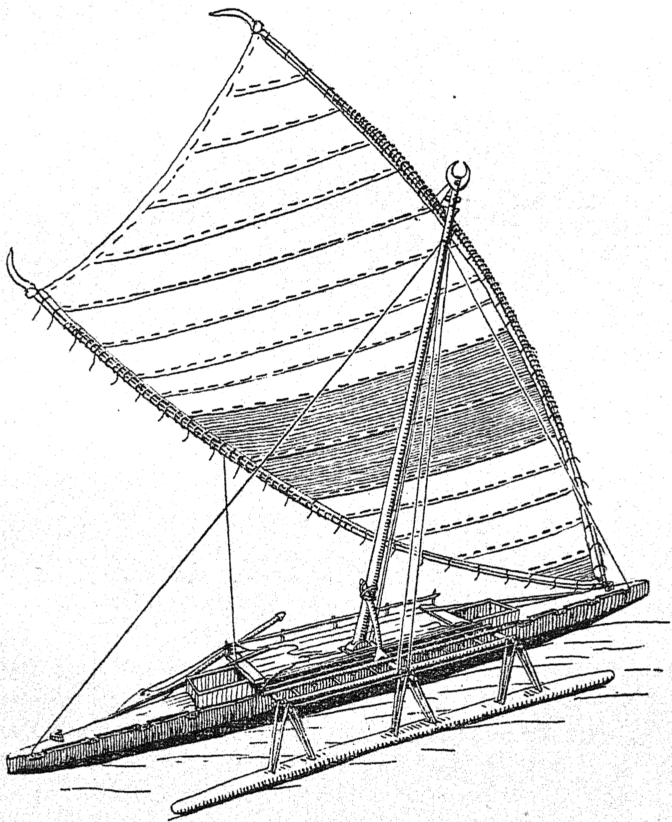


Fig. 112. Fijian *thamakau*

A single-outrigger canoe with Oceanic lateen sail and lee platforms reduced to an almost vestigial form. Drawn from photographs.

result asymmetric, being relatively full on the outrigger side, and practically flat on the lee side; this gives the effect of a leeboard, and these canoes can go to windward better than any others. They are, too, extremely fast for their size. A Gilbert islands canoe, with racing canvas but only 29 ft. over-all length, was once timed to cover a distance of 18 sea miles in one hour. The 'flying proas' of the Marianas described by the early navigators were all of this basic type. Naturally, canoes of this kind required a very high degree of seamanship, and a man was not regarded as a qualified

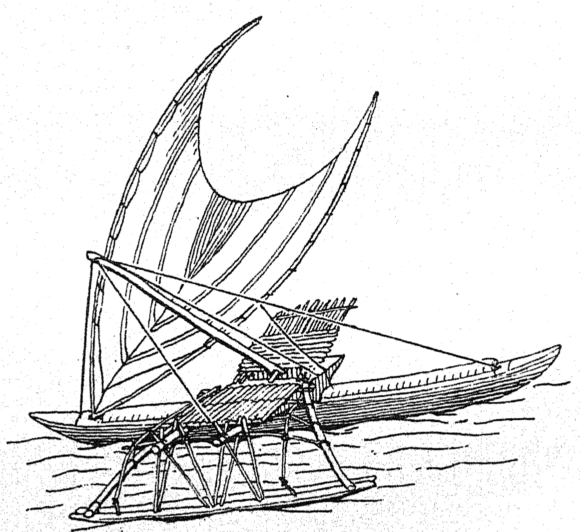


Fig. 113. Reef islands sailing canoe

Note the crab-claw sail, single outrigger and lee platform. Based on A. C. Haddon and James Hornell, 'Canoes of Oceania', vol. II, *Bernice P. Bishop Museum Special Publication*, no. 28, p. 367 (Honolulu, 1936).

helmsman until he could sail such craft for a considerable distance by the sheet alone with the outrigger clear of the water, and without letting it touch the surface during the test—which might include some quite intricate sailing round the edges of reefs.

The influence of these remarkable craft is seen in Fiji, where the same rig is employed, but where the hull is symmetrical and decked at each end (Fig. 112; vol. III, pp. 159–60). The extinct *ndrua*, or so-called double canoe, now no longer used, was also based on the same general principles. It carried the same rig and was sailed in

the same manner and should really be considered as a single outrigger canoe with large hollow float, since the second hull was smaller and always carried to windward.

The white-washed sailing canoes of the Reef islands are sailed in the same manner but carry the Melanesian crab-claw sail hoisted on a vertical mast stepped amidships. They are usually about 30 ft. over-all, with a cylindrical hull, dug out and then decked, with a raised central structure to which are attached outrigger booms and a lee platform (Fig. 113).

Canoes in some other areas, notably Samoa and the Society islands, are single-ended and use is made of a balancing spar when sailing with the outrigger to windward.

In paddling canoes the pull of the outrigger float is not so serious as in sailing canoes, but even then considerable difficulty is experienced in turning to starboard (i.e., away from the outrigger which is usually to port) in a rough sea. Normally no provision is made to counteract the action of the float, but at Vaitupu in the Ellice islands this difficulty is partly overcome by setting the forward end of the outrigger float some 6 in. nearer the hull than the after end. An ingenious arrangement of obliquely set bow and stern sections also helps to give short offset keel ridges. When the canoe pitches in a rough sea, the forces set up by the uneven slopes of bow and stern tend to force the canoe round. But, since the short lengths of keel ridges run fore and aft till they merge in the round midships section of the hull, they do not have any marked effect on the course of the canoe.

Canoes without Outriggers

In New Zealand, where very large trees were available, long dugouts with a broad beam and no outriggers were built. But for all utilitarian purposes they are now obsolete, being used only in regattas on festive or ceremonial occasions. Built-up craft without outrigger are found in Samoa where the native long-boat (*fautasi*) is a copy of European ships' boats, and in the Solomon islands, where plank-built canoes (Fig. 106—no. 4; and vol. III, Plate 107) are found. The essential feature of these remarkable canoes is that they are plank-built with cleats formed on a median ridge running the whole length of the planks. They are lashed by means of these cleats to frames inserted in the hull, a method of construction which has also been found in certain early Viking ships in north-west Europe.

In many of the islands and atolls the flesh of animals is scarce, or is adequate only for ceremonial occasions, and the people depend largely upon fish as a supplement to vegetables in their daily food. The variety of fish caught is great. Apart from species found only in tropical waters, such as flying fish, it includes types such as mackerel, mullet, sea-bream, garfish, bonito, eel, shark and ray. Crabs and shellfish are also taken in quantity, and in some parts of the Pacific use is made of a marine worm commonly known by the Samoan name, *palolo*, which appears in great masses at the surface of the sea only at certain phases of the moon. Very many methods of catching fish are employed. Fishing with hook and line is almost universal in the region. Most of the hooks are now of European manufacture, though some of the large specialized ones are still made locally of wood, and the composite spinners are usually of shell or bone with barb of turtle shell. Nests (Plates 126, 127), frequently made of hibiscus bark, vary in type from a small dip net or a casting net, to a long seine. In the many pools and channels along the reefs multiple-pronged spears are used, and some people of the Solomon islands and New Guinea shoot fish with bow and arrow (Plate 125). Various forms of fish trap are used, from a simple conical frame lined with thorns to a modified kind of lobster pot. In some areas, as in the Tuamotu archipelago, walled fish traps and weirs of stone are used (vol. II, pp. 199–200). In the Western Pacific, particularly, vegetable poisons, such as that obtained from the root and stem of derris or from the fruit of the *Barringtonia*, are used to stupefy fish in streams or pools. Groping with the hands under rocks or in crevices of the reef is a method often used; in some areas this is a highly developed technique, used by expert divers who remain under water for some time, working along the bottom or over a reef face. Perhaps the strangest method of fishing in the Pacific is that used in parts of Melanesia for catching garfish. A kite of palm leaf, with a long extra line attached, is flown from a canoe. To the end of the extra line is fixed a clump of cobweb, and adjustments are so made that the cobweb skips lightly over the surface of the water. It thus acts as a lure for the garfish—perhaps because it resembles a kind of fish on which the garfish preys—and is seized. No hook is needed to hold the garfish since its long teeth become entangled in the web.

Some other specialized methods commonly used in the Pacific

Plate 126. Fishing canoe on the lagoon, Trobriand islands

The large triangular nets seen here are held out close to the water. The fish are driven into seine nets and in attempting to jump over them fall into the triangular nets.

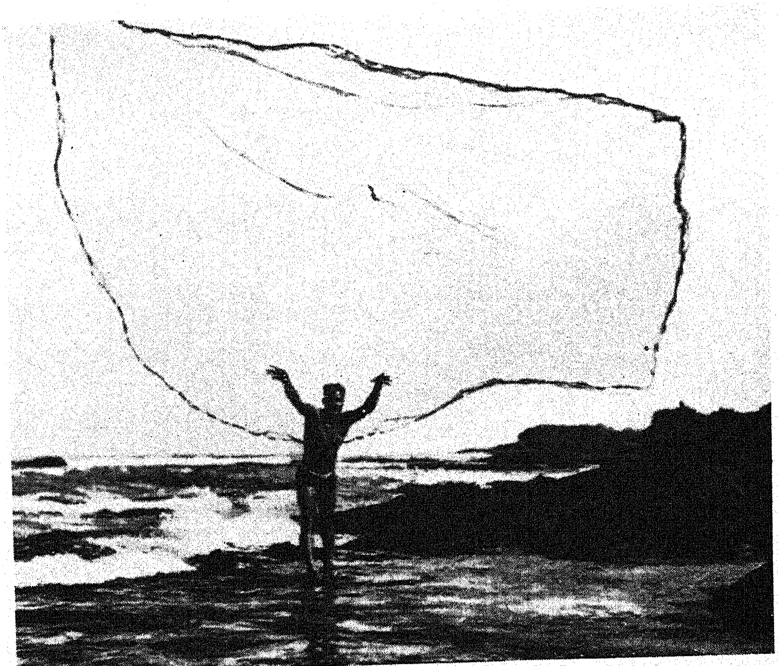
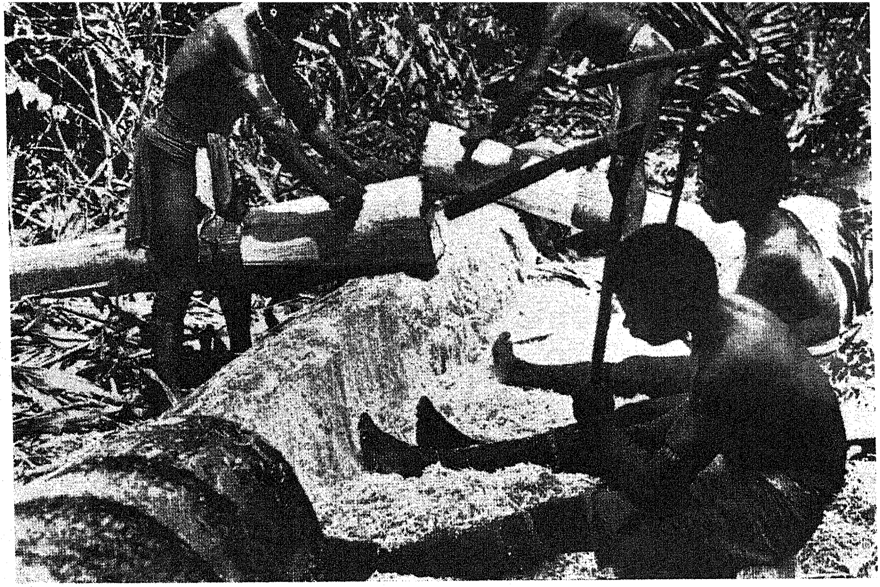


Plate 127. Hawaiian fisherman with throwing net

The fabric is gathered into a bundle, swung and released so that the weights at the edges fly outwards from the centre. The net thus extended is 25 ft. or more in diameter. As it sinks, the weights come together and



Plates 128, 129. Papuans sago-making

Plate 128 (above) shows the grating and chopping out of the pulpy interior of the sago-palm trunk. Plate 129 (below) shows the sago being poured into a trough f... making

for taking particular kinds of fish are described below.

Flying Fish. Flying fish are caught either by day or by night. A frequent method by day is for a dozen or so canoes to line up a short distance off-shore and drive the fish into a deep V-shaped pocket in the reef by beating on the sides of the canoes or splashing with paddles. When the fish are in the pocket, men with dip-nets in the bows of the canoes scoop them out into the bilges of the craft. Sometimes the fish are not driven into a pocket but into a large folding net about 50 ft. long and 9–12 ft. deep. The top of the net is supported in the water by a jointed beam and the bottom is weighted down with small sinkers. The net is arranged in a V-shape and held in position by men swimming. When the fish are driven into it the two sides are brought together, the catch is emptied into a canoe, and the process is repeated. Fish which attempt to escape by flying above the surface are caught in the air by dip-nets. Formerly, in Tongareva, shoals of flying fish were surrounded by a circle of swimmers armed with hand-nets, who caught the fish in the air and in the water, and emptied their nets into the baskets of women who swam behind them.

A most spectacular method of catching the fish is practised on moonless nights. A fleet of canoes sets out and sweeps off-shore in echelon formation. Each canoe has a dip-net at bow and stern and torches of dry coconut leaf. When the fleet is in position the torches are made to flare and the canoes are paddled slowly onwards while the netsmen at bow and stern stand ready. The fish, attracted by the light, rise to the surface and fly above; aided by the wind, they often rise up to a height of 6 ft. or so and travel up to a hundred yards. As they flash past, like silver streaks in the light of the flares, the netsmen skilfully catch them in the long-handled nets, and with a quick turn of the wrist enmesh them, and drop them over the shoulder into the canoe. An expert netsman will take as many as 100 fish in a night if they are plentiful. The scene is an animated one, with the flaring torches, fish rising and skimming past, and the shouts of the fishermen—'Coming over', 'A fish on the port bow', 'A high fish to starboard', and the like.

Bonito. Another exciting occupation is trolling for bonito with one or more spinners from the stern of a paddling or sailing canoe. A stout rod, usually of bamboo set in a wooden socket, is placed in a crotch to project over the stern. To the end of the rod is attached a line (or sometimes several) with a spinner. This consists of a lure, usually made of pearl shell, but sometimes of clam shell,

bone or stone, with a barb or hook, ordinarily of turtle shell, and a hackle of feathers or hibiscus fibre at the rear. The spinners vary in size from about 2 in. to 5 in. Great care is usually taken in making these spinners and, since the pull of the bonito is strong, in binding on the barb with a secure lashing. Experts in bonito fishing often have their own styles of setting the hackles and securing the lashings. In some places, as at Vaitupu in the Ellice islands, the pearl shell is carefully ground to produce differences of colour or sheen—as pearl grey, blue grey or opalescent green—each, in a spinner of appropriate size, resembling the kind of fish on which the bonito are preying when the fishing is actually taking place. So valuable are these bonito hooks that in some islands they are among a man's most prized possessions.

The presence of a shoal of bonito is indicated by the sight at sea of a cloud of sea birds, which are preying on the small fish which the bonito are also chasing. The canoes put out, paddling hard, and follow the shoal, each casting out a spinner as they approach. On feeling a bite the fisherman works the rod with one hand to bring the fish to the surface and then, standing up, he swings the rod with some force so that the fish is flung against his stomach, where he secures it with his forearm and disengages the spinner with his thumb. Dropping the fish into the canoe, he makes another cast, working all the time at high speed, since the shoal moves quickly and may disappear at any moment. The whole operation is one demanding great skill, but there is also a considerable element of chance involved. The fish may make off suddenly before the canoes reach them, may refuse the lure, may break the lashing, or slip off the barb before being brought in; or the spinner may be taken by a kingfish, the sharp teeth of which often cut through the line. The loss of the valued spinner can be a small tragedy to the fisherman. Hence in nearly every community where bonito fishing is practised, it is surrounded by ceremonies and taboos, and a mass of legends and myths has accumulated about it. On the other hand, success in bonito fishing is a mark of real prowess, and experts are held in great esteem. At Vaitupu, where communal bonito fishing expeditions are organized on a competitive basis, sometimes the canoes return to the shore in a kind of triumphal procession, with the craft of the most successful fisherman in the lead.

Shark. Sharks, except a few types regarded as inveterate man-eaters, are not held in such fear by Pacific islanders as they are by Europeans, and they are often treated with surprising familiarity.

The methods employed in taking them are characterized by great coolness, and the situation often takes on the character of a personal combat between the shark and the fisherman. The shark is normally regarded as an ordinary fish—though sometimes an individual is thought to be the incarnation of an ancestor or other spirit and is treated with respect—and its flesh, even that of a man-eater, is eaten.

In many parts of Polynesia the shark is caught by a noose. In Aitutaki, Tongareva, and some other islands, sharks that sleep in channels with their heads in rock crevices are snared by expert divers who go down and slip a noose over the tail. In Samoa and elsewhere the noose is operated from a canoe. The shark is first attracted by noise—in Tikopia, by grating two clam shells together under water; in Samoa, by shaking a rattle of coconut shells under water. Once alongside, the shark is lured into position (sometimes by a bait of meat or fish) and the stout rope noose is then slipped over its head and drawn tight. A struggle then ensues, until the shark can be hauled close aboard and stunned by blows on the nose from a wooden club. With a large shark and a small outrigger canoe, the struggle is sometimes long and not without danger. Fishing with the hook is also common. Nowadays this is sometimes of iron, but is still often of wood; it is usually about 10–11 in. long. The shape of the hook is an even curve, often obtained by bending and tying a young growing branch. Occasionally, a bone barb is attached, but usually the hook is plain, or has a wooden barb cut from the solid. A knob is left at the top of the shank for attachment of the snood, which is made from stout coconut fibre cord served with a very strong lashing to prevent it from being cut through by the shark's teeth.

Ruvettus. The *Ruvettus*, popularly known to Europeans as the castor-oil fish, is taken in many parts of the central Pacific. Though palatable, the flesh is oily, and has a pronounced laxative effect; about 4 oz. is as much as can be eaten without disturbing effects. The fish, which inhabits deep water, is large; specimens are taken up to 60 lb. and more.

Fishing for *Ruvettus* takes place at night. It is caught with a wooden hook baited with the flesh of a flying fish, at depths between about 80 and 250 fathoms; a stone sinker is attached above the hook to keep it down. Owing to the length of the line and its inertia, it is difficult to know immediately when a fish has been hooked, and a specialized hook has been evolved accordingly. The hook is

bone or stone, with a barb or hook, ordinarily of turtle shell, and a hackle of feathers or hibiscus fibre at the rear. The spinners vary in size from about 2 in. to 5 in. Great care is usually taken in making these spinners and, since the pull of the bonito is strong, in binding on the barb with a secure lashing. Experts in bonito fishing often have their own styles of setting the hackles and securing the lashings. In some places, as at Vaitupu in the Ellice islands, the pearl shell is carefully ground to produce differences of colour or sheen—as pearl grey, blue grey or opalescent green—each, in a spinner of appropriate size, resembling the kind of fish on which the bonito are preying when the fishing is actually taking place. So valuable are these bonito hooks that in some islands they are among a man's most prized possessions.

The presence of a shoal of bonito is indicated by the sight at sea of a cloud of sea birds, which are preying on the small fish which the bonito are also chasing. The canoes put out, paddling hard, and follow the shoal, each casting out a spinner as they approach. On feeling a bite the fisherman works the rod with one hand to bring the fish to the surface and then, standing up, he swings the rod with some force so that the fish is flung against his stomach, where he secures it with his forearm and disengages the spinner with his thumb. Dropping the fish into the canoe, he makes another cast, working all the time at high speed, since the shoal moves quickly and may disappear at any moment. The whole operation is one demanding great skill, but there is also a considerable element of chance involved. The fish may make off suddenly before the canoes reach them, may refuse the lure, may break the lashing, or slip off the barb before being brought in; or the spinner may be taken by a kingfish, the sharp teeth of which often cut through the line. The loss of the valued spinner can be a small tragedy to the fisherman. Hence in nearly every community where bonito fishing is practised, it is surrounded by ceremonies and taboos, and a mass of legends and myths has accumulated about it. On the other hand, success in bonito fishing is a mark of real prowess, and experts are held in great esteem. At Vaitupu, where communal bonito fishing expeditions are organized on a competitive basis, sometimes the canoes return to the shore in a kind of triumphal procession, with the craft of the most successful fisherman in the lead.

Shark. Sharks, except a few types regarded as inveterate man-eaters, are not held in such fear by Pacific islanders as they are by Europeans, and they are often treated with surprising familiarity.

The methods employed in taking them are characterized by great coolness, and the situation often takes on the character of a personal combat between the shark and the fisherman. The shark is normally regarded as an ordinary fish—though sometimes an individual is thought to be the incarnation of an ancestor or other spirit and is treated with respect—and its flesh, even that of a man-eater, is eaten.

In many parts of Polynesia the shark is caught by a noose. In Aitutaki, Tongareva, and some other islands, sharks that sleep in channels with their heads in rock crevices are snared by expert divers who go down and slip a noose over the tail. In Samoa and elsewhere the noose is operated from a canoe. The shark is first attracted by noise—in Tikopia, by grating two clam shells together under water; in Samoa, by shaking a rattle of coconut shells under water. Once alongside, the shark is lured into position (sometimes by a bait of meat or fish) and the stout rope noose is then slipped over its head and drawn tight. A struggle then ensues, until the shark can be hauled close aboard and stunned by blows on the nose from a wooden club. With a large shark and a small outrigger canoe, the struggle is sometimes long and not without danger. Fishing with the hook is also common. Nowadays this is sometimes of iron, but is still often of wood; it is usually about 10–11 in. long. The shape of the hook is an even curve, often obtained by bending and tying a young growing branch. Occasionally, a bone barb is attached, but usually the hook is plain, or has a wooden barb cut from the solid. A knob is left at the top of the shank for attachment of the snood, which is made from stout coconut fibre cord served with a very strong lashing to prevent it from being cut through by the shark's teeth.

Ruvettus. The *Ruvettus*, popularly known to Europeans as the castor-oil fish, is taken in many parts of the central Pacific. Though palatable, the flesh is oily, and has a pronounced laxative effect; about 4 oz. is as much as can be eaten without disturbing effects. The fish, which inhabits deep water, is large; specimens are taken up to 60 lb. and more.

Fishing for *Ruvettus* takes place at night. It is caught with a wooden hook baited with the flesh of a flying fish, at depths between about 80 and 250 fathoms; a stone sinker is attached above the hook to keep it down. Owing to the length of the line and its inertia, it is difficult to know immediately when a fish has been hooked, and a specialized hook has been evolved accordingly. The hook is

V-shaped, and usually made from a forked branch. A barb is lashed by a scarf joint to face inwards, but is slightly offset to one side. When the fish takes the bait it tends to swim downwards—i.e., away from the resistance—and this tends to force the leg of the hook across its mouth. Being unable to get away, it works its head about, but only with the result of forcing the barb through its gills or the floor of its mouth. As the fisherman, feeling the pull, hauls in the line, the crotch of the hook slips into the angle of the jaw of the fish, and it is safely secured.

NATIVE MANUFACTURES

The material culture of most of the peoples of the Pacific islands has undergone many changes since the coming of Europeans. Steel tools have replaced those of stone and shell, calico has replaced bark cloth, mats and grass skirts, vessels of clay and wood have given place to those of tin, and matches and kerosine lamps have taken the place of fire plough and candlenut. Likewise, in many areas, traditional crafts have died out or been retained only to a limited extent, often to serve ceremonial needs. But in areas where contact with Europeans has been slight, especially in the interior of New Guinea, or where local resources provide only small exports for cash, or, in times of economic depression when external markets are dull, the old crafts are still important or tend to be revived. A brief account must therefore be given of some of the principal of them. (House-building and canoe-building, to which some reference has already been made, are omitted here.)

Tools

Materials of many kinds are used for tools, depending largely on local resources. They include flakes of obsidian, sharp bivalve shells, slivers of bamboo, sharks' teeth, boars' tusks, and the bones of wallaby and cassowary, as cutting or boring instruments. But the basic working implement, formerly found all over the Pacific and still used in parts of New Guinea, is the axe or adze blade of stone or shell (Plate 124). In the Eastern and central Pacific the adze form alone was used, but in the Western Pacific the axe form (with equal bevel to the edge) was more common and in some parts still obtains. Basalt or other volcanic rock is the usual material, but formerly in the central Pacific the lack of such material led to the use of the shell of the giant clam. Stone axes are hafted in various

Plates 130, 131. Pottery-making at Mailu, off the south coast of Papua Plate 130 (above) shows the early stage of the process in which a pot is built up from a coil of clay. Plate 131 (below) shows the final smoothing of a pot after the coils have been kneaded together; the shell contains water to help in the process of smoothing the pot. Note the women's grass skirts.

Plate 132. A wood-carver at work, mount Hagen area, New Guinea
Note the elaborate head-dress with bird's wings and cowrie shells and the stone adze slung behind the man's back.

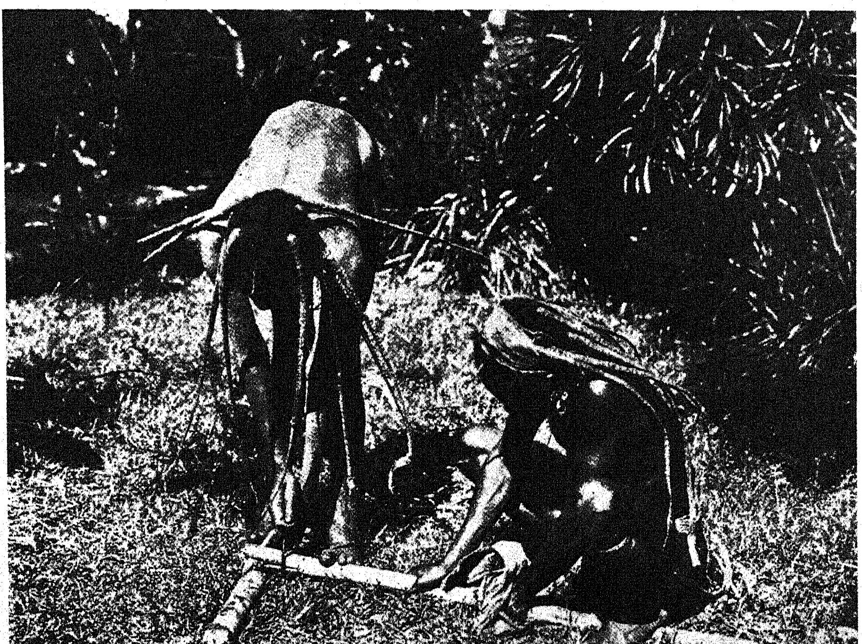


Plate 133. Fire-making in the interior of New Guinea
The kneeling man is holding a split piece of wood, while his companion saws

ways, from insertion in a simple slot in the wooden handle to lashing the blade into a pointed wooden tang and driving this into a hole in the handle. A particularly ingenious method is to haft the blade in a swivelling socket so that it can be used axe-like, cutting in a line with the handle, or adze-like, cutting across the line of the handle. Saws are unknown in the native culture, and planks are either split with wedges or dubbed out of the solid with axe or adze. Holes are bored by various means, such as a sharp-pointed univalve shell, a wallaby tooth bound in a split stick which is rotated between the palms of the hands, or a more elaborate drill. The common form of drill is the pump-drill, a primitive counterpart of that used by a European watchmaker but with a stone or shell point or often nowadays with an iron nail instead. Where matches are not in use fire is produced by drilling a stick into a soft piece of wood or ploughing it rapidly to and fro along a groove in the wood, or by sawing a strip of cane swiftly back and forth around a stick (Plate 133).

Textiles, Mats and Basketry

Textiles and analogous products are made from a variety of materials, including rush or swamp grass, bast, strips of cane, coconut-palm leaflets and other fibres. The articles made include clothing, sleeping mats, baskets for holding fish and other food, bags to carry personal possessions, and mats to cover the floor of a house, and many kinds of twining and plaiting technique are used, some of which produce elaborate ornamental designs.

Textiles produced on a loom are rare in the Pacific, and are wholly absent in Polynesia; they are associated especially with Micronesian culture, although the loom occurs also in the Santa Cruz group and Sikaiana. The mechanism is very simple. In the Caroline islands, for instance, warp threads are wound continuously over two rods placed about 3 ft. apart. On the upper side of the loop so formed, alternate threads are crossed over and under two laze rods, to keep them distinct, and a heddle is attached to the lower set of these threads. The weaver sits with one of the end rods attached to a frame or tree-trunk, and with a strap passing round her back from the end of the other rod. By leaning back she is able to keep the whole apparatus taut (Fig. 114). The weft thread is passed between the upper and lower series of alternate threads. Then the heddle is raised, reversing the position of the two sets of threads, and is passed back. A flat stick, known as a

sword-stick, is used to press the weft threads close together. Material woven on this simple loom is limited in width to about 2 ft., which is the maximum which can be conveniently managed, and is usually only about 6 ft. long.

Far more common in the Pacific is the manufacture of bark cloth, which is made from the inner bark of the paper mulberry (*Broussonetia papyrifera*). This is soaked in water, scraped, and beaten out on a block of wood by a wooden mallet. Much of the product is coarse and rough, but in some areas, including the Hawaiian

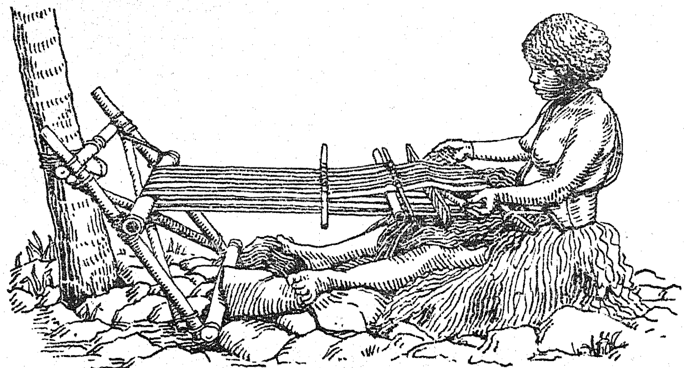


Fig. 114. Woman weaving, Yap

She is using the simple breast loom, which is the only type found in the Pacific. Only narrow material can be woven on these looms. Based on W. Müller, 'Yap', *Ergebnisse der Südsee Expedition, 1908–10*, II (*Ethnographie*), B (*Mikronesien*), Halbband 1, p. 112 (Hamburg, 1917).

islands, the technique was so highly developed that the cloth became almost as fine and soft as paper. In many areas the strips of cloth are fairly narrow, but in some places large sheets are produced by felting strips together or making them adhere by the use of breadfruit gum. Ornamental designs are imparted to the cloth by incising the wooden mallets, or by stencilling or painting patterns on the finished material. Sometimes the cloth is dyed with turmeric, which gives it a brilliant orange-yellow colour. Even nowadays, in some Polynesian communities, large quantities of bark cloth are produced for ceremonial purposes, though it is no longer used as clothing there.

Pottery and Other Vessels

Over a great part of the Pacific, including the whole of Polynesia, no pottery is made, either because of the lack of suitable clay or

Plate 134. A Polynesian creator god
Aa, a god of Rurutu, with small human figures carved on his body, representing his creative activity. Other small figures were found in a hollow in his back.

Plate 135. A wooden figure from Rarotonga
This figure represents Taringanui, a fishing god. It was carried on the prow of a fishing canoe.

Plate 136. Anthropomorphic statuette from the Sepik area of New Guinea

The figure is $21\frac{1}{2}$ in. high. It is of light wood covered with red ochre.

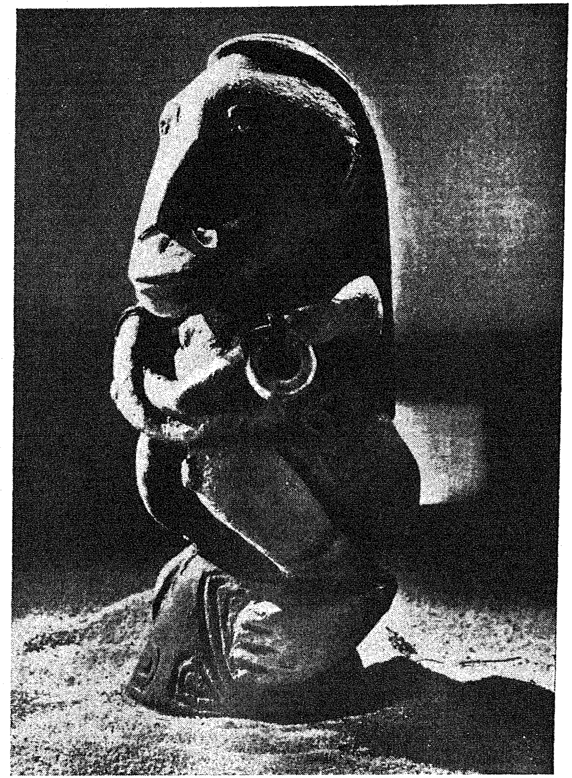


Plate 137. Woman with raincape, lower Sepik river, New Guinea

The figure, $9\frac{1}{2}$ in. high, is of wood, coloured red, with blue beads for eyes.

because the technique is not known. Here the vessels in common use, especially for holding liquids, are of wood and of coconut shell, and occasionally of bamboo. The coconut provides both cup and water-bottle, while larger vessels such as bowls and even troughs are carved from solid blocks of wood. These, however, are not fire-resisting, and so a common method of heating liquids before the introduction of iron buckets and of the ubiquitous kerosine tin, was to slip red-hot stones into the vessel.

In Fiji and many other parts of the Western Pacific, however, while the materials mentioned above are used, pottery is also made, allowing the vessels to be used over a fire. Pottery-making is the work of women. The clay is tempered with sand, and all the processes are done by hand, no wheel being employed. First a lump of clay is worked into the shape of the bottom of the pot, and placed on a base of stone, a broken piece of pot, or a fibre ring, to allow of easy turning. The sides are built up by the successive application of rings or strips of clay (Plate 130). Decorative patterns are sometimes added by incision while the pot is still wet. After drying in the sun for a time the pots are hardened by simple firing. Fijian pots are notable for their translucent golden varnish. Potting is apt to be a localized craft, and trade in pots is an important feature of the native economy around many parts of the coast of New Guinea.

ART

Though the art of the Pacific islands peoples is an important aspect of their culture, only a bare outline of it can be given here. But it may be emphasized that 'savage' as these people were—and as some of them still are—their aesthetic sense is usually well developed. They have a strong feeling for rhythm, design and colour.

In personal adornment they make use of paint, feathers, flowers, seeds and shells (and, nowadays, also beads). They use not only articles of brilliant colour, but also white, which makes an effective contrast against their brown skins. They use also as ornaments, hair combs, nose rings, ear-rings and breast plaques, some of these being objects of considerable beauty of workmanship. Such, for instance, are the combs of Malaita and New Georgia, the handles of which are decorated with finely-wrapped strips of cane in delicate geometrical designs of red, yellow and black, or the breast plaques of Santa Cruz, with white discs of clam shell on which are superimposed filigree patterns in turtle shell. In parts of Polynesia,

especially in the Marquesas, tattooing of the face and body was formerly in vogue, and this practice still obtains in Samoa, where young men often have their thighs elaborately tattooed in geometrical designs, and in Tikopia, where face, chest, arms and back may be ornamented by figures of fish and other patterns. Personal adornment comes to the fore particularly at times of communal recreation, when song and dance reveal another strong aesthetic interest of the people.

Their songs usually sound strange and harsh to European ears, especially since beauty of voice of an individual singer is not normally an important criterion. The tonality is usually simple, with narrow compass and small intervals—some of them less than our semi-tone. They are commonly based on the pentatonic scale. But there is wide variation and sometimes considerable compass. In Polynesia there is often part-singing, either with one part holding to a monotone while the other rises and falls around it, or with different voices embroidering variations on a theme. And amidst the barbaric character of most of the songs, one is occasionally struck by the poignant sweetness of a melody. There is little singing for its own sake—though a person may hum a tune as he goes along a path—and songs normally are the accompaniment to some social event, such as mourning or dancing. Dancing is highly stylized, and with the rhythm strongly marked, either by song or by a simple percussion instrument of the drum or gong type. It is usually a group performance (dancing in pairs in European style is unknown) but on occasions individual dancers take the floor for solo work. Here there is more freedom of expression, especially in mimetic dances, in which animals are imitated, events re-enacted, or myths dramatized. Dancing is usually bound up with singing, and the song often refers to the events celebrated or portrayed in the dance. In some communities dances and songs, especially those connected with ritual, are treated as private property; they may be performed only by the individuals or groups who own them or who have obtained permission from the owners.

In the plastic arts there is great variety of treatment, and almost every people has its own aesthetic idiom. But art is so closely linked with other aspects of culture that the breakdown of many traditional institutions owing to European influence has caused a great deal of the former art to disappear or to become degenerated in style. This is specially noticeable in Polynesia. Much of the art of the people is essentially decorative in character, ornament

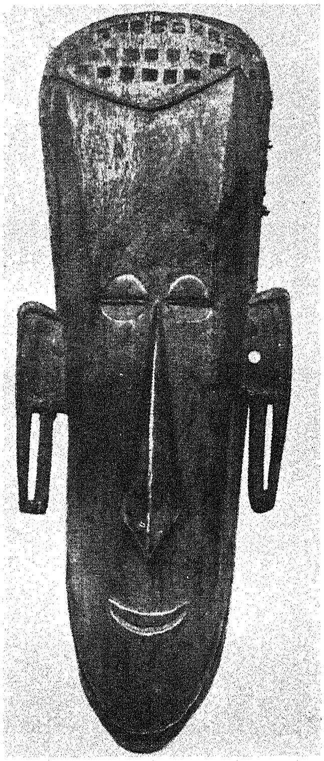


Plate 138. Wooden mask from the western islands of the Torres strait area

This mask is 23½ in. high. It is carved from coffee-brown wood and is highly polished. Masks of this type were worn at a ceremony performed before harvest to ensure a good crop.

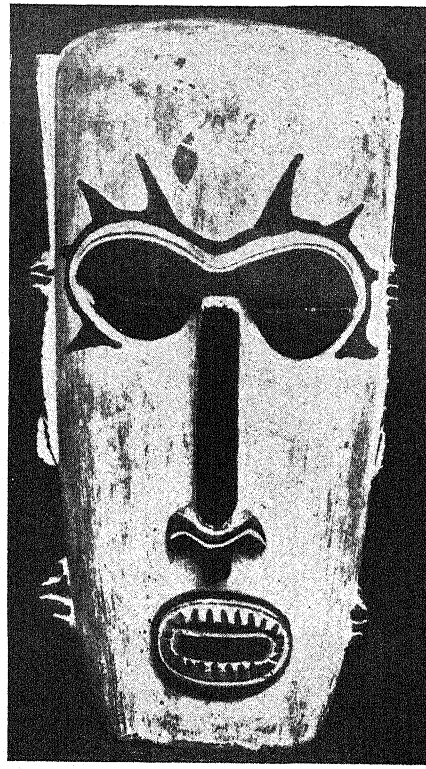
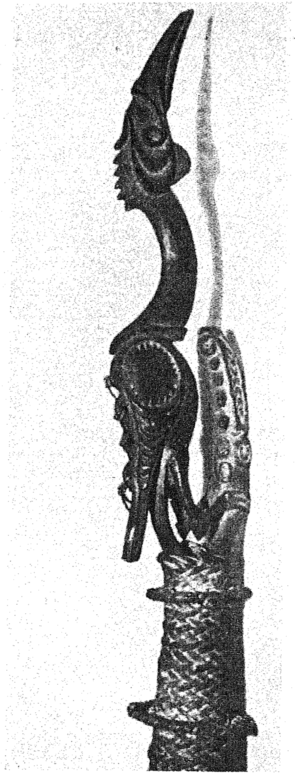


Plate 139. Ghost-dance mask made by the Tami of the Huon gulf, New Guinea

This mask, 15 in. high, is whitened. The nose, eyebrows, tongue and lips are painted red. The wings of the nose and the pattern on the forehead are painted black. Such masks were worn during the meetings of a secret society.



Plates 140–2. The art of the middle Sepik area, New Guinea

Plate 140 (left) shows a drum carved from a single log of wood. The wood is light brown and the drum is partly coloured red and white. A hornbill rests on the human head. Height 23 in. Plate 141 (centre) shows the top of a lime container; the wooden figure represents a hornbill grasping a crocodile's head and is probably of totemic significance. Plate 142 (right) shows a gable ornament from a men's house at Awatib. The figure is 34 in. high. The eye and ear ornaments are of pearl shell.

being applied to a surprising range of objects which are primarily utilitarian. The handles of adzes, wooden bowls and lime spatulae are often elaborately carved; the lashings which hold together the timbers of a house or the reed panels of its sides are often arranged in symmetrical patterns; baskets, sleeping mats and fans are adorned by varying the spacing of the elements in plaiting or by introducing coloured threads; lime gourds and bamboo tobacco pipes are covered in intricate pokerwork or incised designs. But, as in medieval Europe, a great deal of the art is applied to religious and allied cult purposes. Figures of gods, totemic ancestors and other spirits, masks for ritual dances (Plates 138, 139) charms and receptacles to hold them, posts and gables of temples or other ceremonial buildings show some of the most striking developments of the native artistic capacity. In all this, however, artist and craftsman are one; there is little suggestion of 'art for art's sake,' and though there is considerable aesthetic appreciation of the results, these are viewed by the public in terms of their utilitarian or ritual functions as well. Moreover, they are often as much interested in the symbolic content of the design as in its formal character.

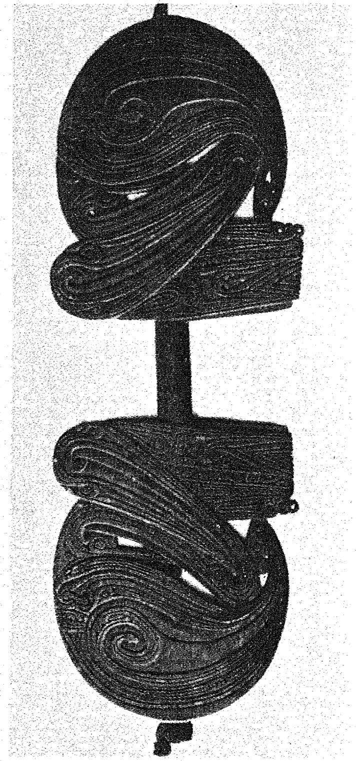
The motifs employed are of great variety. They vary from simple geometrical patterns of curvilinear (Plate 144) or rectilinear type, to bird and animal representations, sometimes fairly naturalistic but often highly conventionalized (Plates 119, 140, 141). In addition, anthropomorphic figures (Plates 136, 137, 142) are often reproduced, usually with even less attempt at natural portraiture, but with emphasis and distortion of certain features, such as face, nose or sex organs, according to their social or religious importance. An interesting example of such treatment is the image of Aa, chief god of Rurutu in the Austral islands and apparently a creator deity (Plate 134). The image is ornamented with small human figures cut on its surface in high relief, and so arranged on the face that they take the place of eyes, nose, mouth and ears, yet preserve the formal impression of these features.

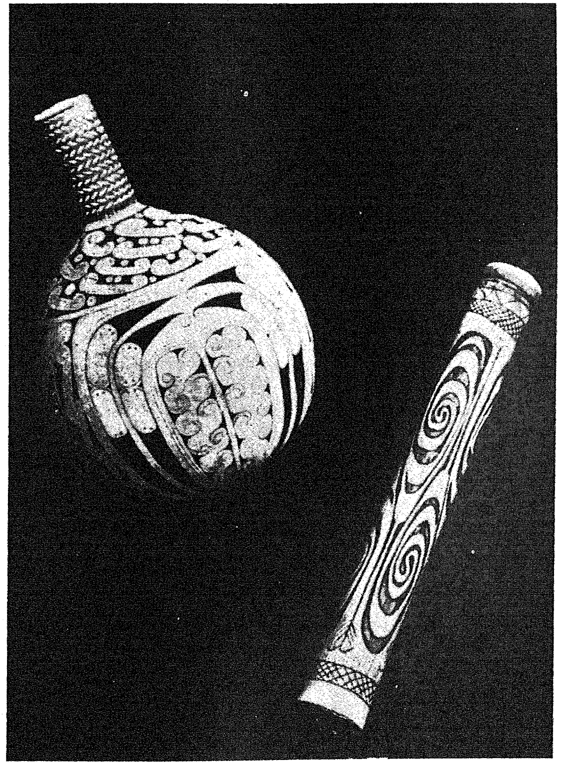
RELIGION AND MAGIC

Throughout nearly the whole of the Eastern and central Pacific and in much of the Western Pacific as well, the people are now Christians. Most of the old beliefs and rites have disappeared, the church is one of the most important buildings in the village, if not the outstanding one, on which much of the traditional artistry is

lavished (Plate 148), the European missionary or native teacher is one of the most influential leaders of the community, and the people devote to church festivals and collections much of the energy and wealth they formerly applied to their ancient cults. But the transition is by no means always complete. Beliefs in the power of the old spirits still are apt to survive, and emerge particularly when people fall sick; and recourse is still often had to magical practices to obtain success in fishing or to ward off ill-luck and witchcraft. Again, symptoms of an underlying strain, of the lack of complete adaptation, sometimes become manifest in new religious cults. These may either combine native and Christian elements, as did the Hauhau cult of the Maori, the Tuka cult of the Fijians and reversionary movements in the Society islands and Hawaii in the nineteenth century, or they may assume a prophetic or faith-healing form by pushing still further the interpretation of certain Christian tenets or Biblical texts, as did Rua Kenana among the Maori in more recent years or a native pastor in the Gilbert islands in 1930. Similar in type, though not incorporating Christian elements, are cults such as the Vailala madness and the Taro cult in New Guinea or the Water Babies of Fiji, produced by native leaders claiming to have new formulations or revelations of the old beliefs. Some of these cults assume an anti-European character, others exhibit a fierce sectarianism, others merely call to a new way of life. But the essential feature of all of them, sociologically speaking, is that they attempt to provide a spiritual outlet to a people who have found a lack of adjustment between their own way of life and the new social and economic order, including the Christian faith.

The traditional native religions of the Pacific still flourish in many parts of the Solomon islands, the Bismarck archipelago and New Guinea. They present a great variety of belief and ritual, which cannot even be summarized here. But in general, they embody belief in a number of gods and spirits, with power to assist or harm mankind and needing propitiation by the performance of the appropriate rites and invocations, and by offerings of food and other objects. These gods and spirits are usually closely linked with the social organization of the people, being commonly regarded as the creators or ancestors of the people, and often as involved in a social system parallel to that of the human groups in the society. Sometimes they are of totemic character, being associated with particular species of plant, animal or insect. They are believed to enter into the life of the people in many ways, but especially in the





Plates 143, 144. Examples of curvilinear decoration from New Guinea

Plate 143 (left) shows a dancing shield from the Trobriands; such shields are carried in the hand by men in the *kaydebu* dance. Birds and snake elements are present in the design. Length $30\frac{1}{2}$ in. Plate 144 (right) shows a lime gourd from the Massim area (above) and a bamboo case from Geelvink bay, Dutch New Guinea (below). The gourd has a diameter of $7\frac{1}{4}$ in.

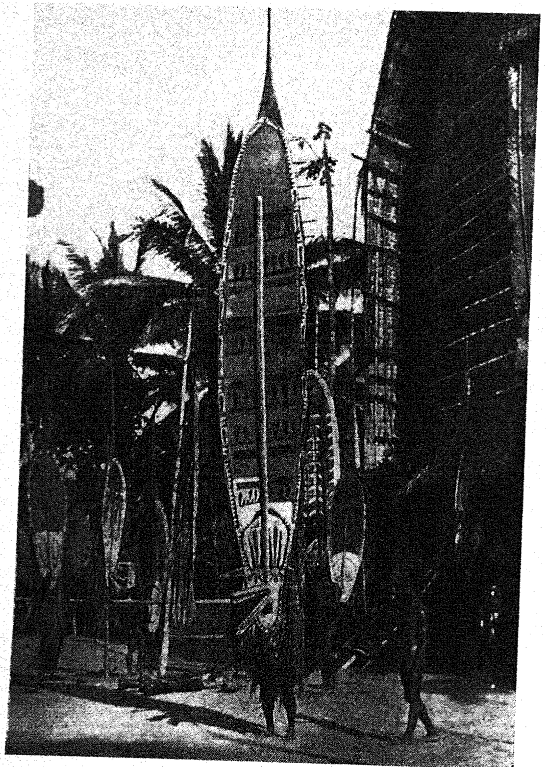


Plate 145. A candidate for initiation, Orokolo bay, Papua
The candidate is masked and is dancing.

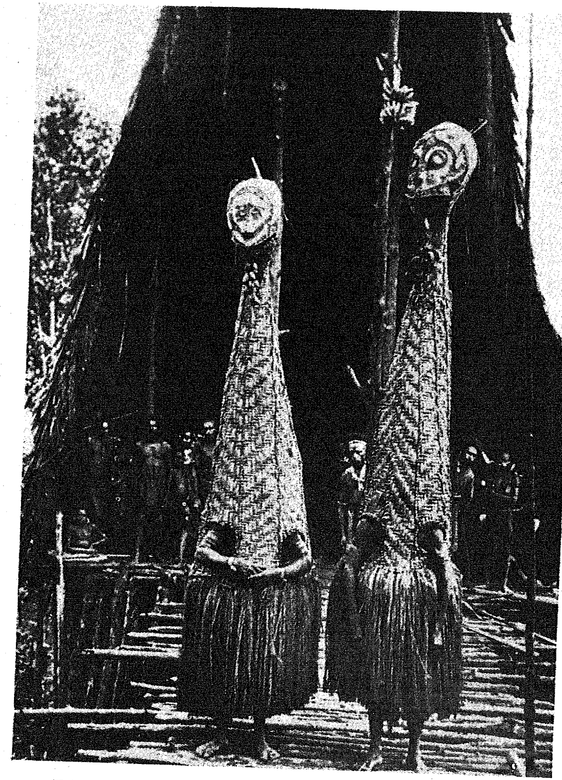


Plate 146. Taboo goblins of Urama, Papua
These goblins are used by the old men to keep the village under control and to guard the crops at harvest time.

major occupations, such as agriculture and fishing, and in the rites associated with the initiation of boys into adult life. In these initiation ceremonies, sacred objects such as bullroarers, flutes and masks (Plates 139, 145) are shown to the initiates and used by them for the first time; they are also told the myths of origins of the people and their institutions. Among some of the New Guinea peoples, head-hunting and cannibalism are practised; both these customs usually have definite religious associations. As a rule, the native religions of the Pacific provide little in the way of moral sanctions, though some of the myths do give a kind of explanation and charter for moral conduct. Again, beliefs regarding the world after death are often vague; the afterworld is conceived as being much like the state of men on earth, with the same social distinctions and occupations, but the details are not usually clearly formulated. There is rarely any idea of good or evil conduct in this world affecting one's position in the next. In contrast to this, however, there are usually elaborate beliefs concerned with the ways in which spirits of the dead communicate with the living, and vice versa, as in dreams, spirit seances, etc.

Side by side with the native religion, and often difficult to distinguish from it, is magic. In this, the emphasis is not upon the power of spirit beings, but rather on powers of a supernormal order emanating from man himself, and control is exercised not by invocations and offerings, but by spells and charms. (The distinction is a very broad one, and many phenomena of an intermediate type are often termed 'magico-religious'.) Most of the Pacific islands peoples—even those who have accepted Christianity—have a firm belief in the power of magic. Spells and charms are regarded as efficacious for making crops grow, for catching fish, for allaying wind and weather at sea, for securing the affections of a loved one, and for the cure of illness. Moreover, a very important set of beliefs is associated with black magic (variously known also as sorcery or witchcraft). In many communities it is believed that a sorcerer, by securing some of the personal leavings of his intended victim—such as hair, excreta, or remains of food—can by means of spells strike the other person with illness and even death. A known sorcerer, a person who is believed to practise sorcery, is greatly feared. When a person is ill or has died it is common for the kinsfolk to seek revenge, and the violence or killing that sometimes results has led some governments to put sorcery under a ban and punish those who acknowledge themselves to be sorcerers. On

the other hand, every magic has its counter-magic, and the primary role of some sorcerers is regarded as being the punishment by supernatural means of those evil persons who have been responsible for the illness and death of others, and they are therefore thought to be performing a social service. The whole problem of sorcery in modern conditions is a complex one, especially since with the lack of scientific knowledge of the causation of disease, these native peoples are firmly convinced that their own magical beliefs and practices offer both an explanation of disease and a remedy for it.

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General works on the Polynesians include: Peter H. Buck (Te Rangi Hiroa), *Vikings of the Sunrise* (New York, 1938); and 'Polynesian Anthropological Studies' (a collection of articles by various authors), *Memoirs of the Polynesian Society*, vol. XVII (New Plymouth, 1941). Both of these, however, deal mainly with the ancient culture of the people. Good accounts of modern Polynesian peoples are: Felix M. Keesing, *Modern Samoa, Its Government and Changing Life* (London, 1934); Ernest and Pearl Beaglehole, 'Pangai Village in Tonga', *Memoirs of the Polynesian Society*, vol. XVIII (Wellington, 1941).

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Apart from these, useful studies of various aspects of the social anthropology of Pacific islands peoples include: Beatrice Blackwood, *Both Sides of Buka Passage* (Oxford, 1935); Gregory Bateson, *Naven, A Survey of the Problems Suggested by a Composite Picture of the Culture of a New Guinea Tribe drawn from Three Points of View* (Cambridge, 1936); Raymond Firth, *We, The Tikopia: A Sociological Study of Kinship in Primitive Polynesia* (London, 1936); Raymond Firth, *Primitive Polynesian Economy* (London, 1939); Raymond Firth, 'The Work of the Gods in Tikopia', *London School of Economics Monographs on Social Anthropology*, nos. 1–2 (London, 1940); R. F. Fortune, *Sorcerers of Dobu* (London, 1932); Bronislaw Malinowski, *The Sexual Life of Savages in North-Western Melanesia* (London, 1932); Bronislaw Malinowski, *Crime and Custom in*

Savage Society (London, 1926); Bronislaw Malinowski, *Coral Gardens and Their Magic*, 2 vols. (London, 1935); Bronislaw Malinowski, *Argonauts of the Western Pacific* (London, 1922); Margaret Mead, 'Social Organization of Manua', *Bernice P. Bishop Museum Bulletin*, no. 76 (Honolulu, 1930); Margaret Mead, *Coming of Age in Samoa* (New York, 1928; London, 1929); Margaret Mead, *Growing Up in New Guinea* (New York, 1933; London, 1931); F. E. Williams, *Orokaiva Magic* (Oxford, 1928); F. E. Williams, *Orokaiva Society* (Oxford, 1930); F. E. Williams, *Papuans of the Trans-Fly* (Oxford, 1936).

There are many publications on the arts and crafts of Pacific islands peoples. Among the most comprehensive or interesting works are: Raymond Firth, *Art and Life in New Guinea* (London and New York, 1936); A. C. Haddon, 'The Decorative Art of British New Guinea', *Royal Irish Academy, Cunningham Memoirs*, no. 10 (Dublin, 1894); A. C. Haddon and James Hornell, 'Canoes of Oceania', 3 vols., *Bernice P. Bishop Museum Special Publication*, nos. 27–9 (Honolulu, 1936–8); Te Rangi Hiroa (Peter H. Buck), 'Samoan Material Culture', *Bernice P. Bishop Museum Bulletin*, no. 75 (Honolulu, 1930); K. Von den Steinen, *Die Marquesaner und Ihre Kunst*, 3 vols. (Berlin, 1925, 1928); F. E. Williams, *Drama of Orokolo* (Oxford, 1940).

Chapter XIV

GOVERNMENT AND SOCIAL SERVICES

Government and social services form parts of the broad structure of society. Their scope and their characteristics are closely related to the social and economic system of the territory over which they extend. In territories such as those of the Pacific islands, however, where final legislative and executive control resides in some body outside the territory itself, a further controlling factor exists—the interests and aims of the government of the metropolitan country. Thus, in the economically advanced Territory of Hawaii, the range of governmental activity is wide, and the forms of government closely resemble those of a state government in the United States of America. In Fiji, which is less advanced, the government is significantly less active in some spheres, such as that of education, while political structure embodies some institutions common to most British colonies and others which have grown out of study of local conditions. Or, again, in the French Establishments in Oceania, the system of government shows the influence not only of general French policy but also of a hundred years' experience of local conditions.

The most notable characteristic of the Pacific islands region is the large number of separate administrations extending over minute land areas and concerned with the affairs of extremely small populations. Very simple administrative systems result. In the French dependency of Uvea and Futuna, for example, the Resident controls all major political affairs and acts as magistrate, and he is usually a qualified medical man able to take charge of the hospital on Uvea. He is the only European official in the dependency, and local government is largely in the hands of the native king, chiefs and councils.

In some areas there is even greater simplicity. Pitcairn, for example, though under the general control of the British High Commissioner for the Western Pacific, is wholly administered by a committee of local residents.

CENTRAL GOVERNMENT

Legislative and Executive Control

The methods by which the various states legislate for their Pacific dependencies differ considerably. In Great Britain, Parliament has largely delegated its power to the Crown, so that even the establishment of a colonial constitution is not an occasion for Parliamentary legislation. Similarly in France, most colonial legislation is by decree. In Japan, the powers of the Diet do not extend to the mandated islands, so that legislation is wholly by Imperial ordinance. The United States Congress and the Parliaments of the Australian Commonwealth and New Zealand, on the contrary, have continued to exercise their powers. The constitutions of Hawaii, Papua and Western Samoa, for example, were directly enacted by these bodies respectively. Both the United States and France have made provision for the direct representation of their major territories in the metropolitan government. Thus, the people of Hawaii elect a delegate to the American House of Representatives, where he may speak in debates but not vote. Neither New Caledonia nor the French Establishments in Oceania share the privilege of many other French colonies of electing members to the Chamber of Deputies, though a bill to accord this right to New Caledonia was accepted by the Chamber in 1939 and abandoned only because of the outbreak of war. They do, however, both elect representatives to the French Superior Colonial Council. Frequently members of the Chamber of Deputies have been chosen for this office by the electors, so that the colonies have gained, in a sense, indirect parliamentary representation. Great Britain, Austria and New Zealand have made no move in the same direction. On the whole, however, the people of the Australian and New Zealand dependencies have gained more from geographical contiguity to the Dominion capitals than those of the French dependencies from formal constitutional arrangement. Visits to the islands by Dominion Parliamentarians and to the Dominions by leading island residents have often had a significant effect upon the formulation of policy.

In the islands, the controlling state is generally represented by a

governor or administrator. In most of the major territories he is assisted in executive matters by an advisory council (known in British territories as an Executive Council, in French territories as a Privy Council). This council is generally composed partly of officials and partly of non-officials, the latter most often being nominated by the governor himself with a tacit understanding that he chooses 'representative' men.

In legislative matters, the people of the islands, native and non-native, have generally shown a strong desire to be consulted, while governments, for their part, have usually wished to be able to sound local opinion before framing their proposals. Thus, where it has been possible, some form of legislative council or assembly has been set up. Elected representatives possess the most extensive powers in Hawaii and Tonga. The former territory has a bi-cameral legislature in which all the members are chosen by popular election. The Governor has the power of veto over its acts and provision exists for the carrying on of the government should the legislature refuse supplies, but to it alone Congress has delegated the power of making laws. The upper house, the Senate, possesses the additional power of veto over a large number of the Governor's executive appointments. The Tongan Legislative Assembly, which is uni-cameral, consists of 7 members elected by the nobles of the kingdom, 7 members elected by male taxpayers, and the members of the Cabinet (who are appointed by the Sovereign). It has wide powers of legislation and of control of finance.

In the legislatures of all other island territories representatives of the people form only a minority of the members. This is largely because of the existence, in the major territories, of a relatively complex social structure in which most of the key positions are held by Europeans, who form only a small minority of the total population. In Fiji, for example, the Legislative Council has 32 members, made up of the Governor, 16 official members, and 15 unofficial members. The latter represent the European, Fijian and Indian communities in equal numbers and comprise 5 nominated Fijian members, 2 nominated and 3 elected European members, and 2 nominated and 3 elected Indian members. Similarly, in Western Samoa the Legislative Council consists of the Administrator, 6 official members, 2 elected European members, and 4 nominated native members. In both these territories, however, the governments have established additional bodies, modelled more on native lines, as the primary instruments for the expression of native

opinion (p. 470). In the less advanced Melanesian territories administered by Great Britain or Australia the constitutions are still less advanced. European unofficials sit as nominated members on the Legislative Councils of Papua and the Mandated Territory of New Guinea; but in neither of these areas are natives directly represented in the central government.

Legislative power in the French colonies is concentrated in the hands of the governor, who possesses a not very clearly defined power of legislating by *arrêté*. The more important of these acts are referred to the Minister of Colonies in Paris for approval before being put into operation. Such reference, however, is often in very general terms; the main outlines alone of an *arrêté* will be communicated by cable, and approval will be given before the actual text has been seen. The only organs of popular representation are the General Council in New Caledonia and the Economic and Financial Delegations in French Oceania. The former is a body of 16 elected members, of whom 5 represent the commune of Noumea. Its powers are those of determining the basis and the methods of collection of taxes, other than customs duties. The latter body is partly nominated and partly elected by very restricted constituencies —local governing bodies and the Chambers of Commerce and Agriculture. It is concerned solely with economic and financial matters, and its influence does not appear to have been very large.

In a number of other territories governments are assisted by advisory councils. In many ways the most interesting of these is the Guam Congress. It is composed of two houses—a House of Council, with 16 members; and a House of Assembly, with 27. Both houses are elected biennially by the people. Although the Congress has no legislative powers, it has proved an effective forum from which politically conscious natives can make their views known both to their American rulers and to their fellow-citizens. Its most directly important function is that of electing a committee of three members of each house to sit every month with the governor to advise him on general policy. Elsewhere advisory bodies are generally organized on a much less elaborate scale. An example is the Advisory Council in the British Solomon Islands Protectorate; this has been composed in recent years of three senior officials and four nominated non-officials, with the Resident Commissioner of the Protectorate as chairman.

A number of territories—including the Gilbert and Ellice Islands Colony and American Samoa—have neither legislative nor executive

councils, so that their administrators have unfettered control within the limits allowed them from above.

Both Great Britain and France have overcome some of the disadvantages of the small size of their island territories by placing the smallest of them under the central control of a High Commissioner. Both the British office of High Commissioner for the Western Pacific, created in 1877, and the French office of *Commissaire général de la République française dans l'Océan Pacifique*, created in 1900, were originally designed for the purpose of extending jurisdiction over British and French nationals respectively in islands in which no Western government existed. The rapid completion of the process of annexation in the years after 1890 (pp. 325–9), however, quickly made this purpose anachronous; and the High Commission organizations became the chosen instruments for the control of the newly annexed territories. Notably, they proved the most suitable instruments for controlling the New Hebrides Condominium, which was established by the two Powers in 1906. The Anglo-French agreement provided for the setting up of a condominium government, controlling a number of joint services, and in addition for the establishment of separate British and French administrations concerned mainly with the protection and control of British and French subjects respectively. The two High Commissioners were made joint executive heads of the condominium government and, separately, the heads of their own national administrations. In addition, the British High Commissioner—an office held by the Governor of Fiji—is chief executive officer of the Gilbert and Ellice Islands Colony, the British Solomon Islands Protectorate, and the Pitcairn group. The French High Commissioner—an office held by the Governor of New Caledonia—is, in a similar fashion, charged with the administration of Uvea and Futuna.

Administrative Organization

As in other colonial regions, the small size and impermanence of the European community and the backwardness of a high proportion of non-Europeans, has made it necessary in most parts of the Pacific to bring in most of the higher administrative officers from outside. The only territories which are self-sufficient in this respect are Hawaii, where not only Europeans but Hawaiians, Chinese and Japanese have shown themselves capable of filling the more important offices, and, at the other end of the scale, areas such as Pitcairn,

which are so small and remote that no complex problems ordinarily arise. Tonga also is nearly in this position. The number of posts now filled by Europeans in the government of that kingdom is quite small.

The employment of outsiders in administration has some advantages in areas where the population is racially and culturally mixed. Members of local European minorities in some parts of the Pacific, such as New Guinea, frequently hold views of the political incapacity of the native majority based more on their own hopes, fears and interests than on rational analysis. On the other hand, the employment of non-residents created a number of difficulties. Most important, perhaps, is the considerable increase in cost and the almost inevitable failure of many newly arrived officials to understand the intricacies of local problems and of the local point of view. It is thus especially desirable that such men should be of more than average ability and have received some training in the elements of colonial administration.

The degree to which the countries administering Pacific island territories have recognized this need differs widely. Both Great Britain and France have highly developed systems of civil service organization for their colonial territories. In the colonies of both countries the higher posts are usually filled by officers recruited in the home country and given special training before being posted abroad. Subordinate officers are, where possible, recruited locally. In the British system, there are unified administrative, legal, medical and other specialist services for the whole colonial empire. University graduates are usually appointed, and salaries and conditions of work are designed to attract candidates of high ability. Courses of training for the administrative service—the largest and in many respects the most important of the services—include law, native languages, anthropology, colonial history and geography, besides subjects of strictly practical interest, such as tropical hygiene, surveying and accountancy. Under the French system, those selected for admission to the corps of *Administrateurs des colonies*, who may or may not have already received university training, take a course lasting three years at the *École Nationale de la France d'Outremer*. The Australian government has adopted an interesting variant of this policy in providing an administrative service for Papua and the Mandated Territory of New Guinea. Accepted candidates, who are usually members of a university, are sent immediately to the territory for which they have been selected, where they remain

for about two years with the status of cadets; at the end of that period they return to Australia and attend courses at the University of Sydney in anthropology, law, hygiene, etc.

The governments of the United States and New Zealand have not so far taken any special steps for the training of officers in their Pacific island territories, although important bodies of opinion in both countries have for some time been aware of the need for such action. Japan similarly has not felt the importance of special training. The Japanese policy of large-scale immigration and rapid cultural assimilation of the native peoples has placed the emphasis on the retention of Japanese forms and not upon their adaptation. Japanese officials have not been looked upon as a corps of *élite*, in the same way as Europeans have generally been in areas with a large native population. Even among policemen and public school teachers a large majority are Japanese.

Except in the Japanese mandated islands, natives are widely employed in the public services. Nearly everywhere they provide the bulk of the police force and, where the educational standard is high enough, they fill most of the subordinate clerical posts in government offices. Many more are associated with the machinery of native local government (pp. 467–72).

Finance

The sources of government revenue and the principal objectives of expenditure are a primary indication of the maturity of a colonial administrative system. In a backward colonial area revenue tends to be obtained mainly from customs duties, from royalties on production (where there is mineral development), and from direct and only roughly graduated imposts on the mass of the population. This generally indicates both a paucity of other possible sources of revenue and the absence of administrative machinery suitable for the imposition of more complicated forms of taxation. Expenditure, under the same conditions, is likely to be largely upon official salaries and the more essential public works, such as the erection of buildings to house government departments. When a more advanced stage of development is reached, revenue becomes more diversified, and there is a big increase in expenditure on public works and social services.

A comparative analysis of the budgets of Pacific island territories is possible only in general terms, owing to differences in methods of accounting and to the inadequacy of published figures in many

instances. The relationship between economic and political development, on the one hand, and the characteristics of public finance, on the other, can best be illustrated by reference to changes in one territory over a period of time. The situation in Fiji before about 1900 exemplifies the simplest form of financial structure. From the annexation of the islands in 1874 till the beginning of the present century, Fiji suffered from an almost continuous period of low prices for its principal products. In the absence of financial assistance from Great Britain, the civil service had to be kept so small that for many years it could do little beyond maintaining law and order. During this time native taxes formed one of the principal sources of government income: in 1878 they accounted for 32% of the total, in 1897 for 26%. In the latter year only 6% of total expenditure was allocated to public works, for nearly all was absorbed in the payment of salaries. After 1900, however, the colony found an increasing prosperity through the expansion of the sugar industry, under the leadership of the highly capitalized Colonial Sugar Refining Company. As a result customs revenue swelled enormously and new forms of taxation became possible. It then became unnecessary to take so much directly from the natives, even though, to the

Customs Revenue in Pacific Island Territories
(*as percentage of total revenue*)

Territory	Year	Percentage
Fiji	1937	50
British Solomon Islands Protectorate	1936–7	69
Tonga	1937–8	45
Papua	1937–8	58
Territory of New Guinea	1937–8	53
Western Samoa	1937–8	66
New Caledonia	1929	47

In calculating these figures the revenue of self-balancing departments—e.g., the post office, or government plantations—has been excluded from the total. The figure for Papua includes also excise revenue. Based on: Colonial Office, *An Economic Survey of the Colonial Empire* (*1937*), pp. 511–35 *passim* (London, 1940); Commonwealth of Australia, *Territory of Papua. Annual Report for the Year* 1937–1938, p. 52 (Canberra, n.d.); Commonwealth of Australia, *Report . . . on the Administration of the Territory of New Guinea*, . . . 1938 . . . 1939, pp. 106–7 (Canberra, 1940); New Zealand, *Annual Report . . . on the Administration of the Mandated Territory of Western Samoa* for 1937-8 (Wellington, 1939); Louis Rolland and others, *Législation et finances coloniales*, p. 663 (Paris, 1930).

extent that they shared in general prosperity, they were better able to pay. By 1907 native tax accounted for only 9% of total revenue; by 1937 it accounted for only 1%. In the latter year import duties still represented 50% of the total, but the remainder was made up from many sources—8% from fees of court and office; 7% from income tax and residential tax; just under 5% from interest; and so on. On the side of expenditure, there was a growing surplus after provision had been made for the payment of salaries. In 1907 13% of total expenditure was on public works; in 1937 36% was so spent. And expenditure on education grew similarly.

The finances of Fiji remain typical of those of colonial areas generally—including most Pacific island territories—in their dependence on customs revenue.

The figures in the above Table may be compared with those for colonial areas in other parts of the world. In 1935 customs and excise revenue combined contributed 79% of total revenue in the Gold Coast, 54% in Nigeria, 67% in Sierra Leone, and 39% in Northern Rhodesia. This extreme dependence on customs produces marked financial instability, for the inflow both of consumption goods and of capital goods fluctuates violently with changes in general economic conditions. Of the former, a large proportion are usually for use by natives, who—at least in the more backward territories—are able to dispense almost completely with imported goods when money is scarce. Of the latter, a similarly large proportion are brought in as a result, direct or indirect, of foreign investment, which is equally subject to variation. In some circumstances customs revenue may rise under conditions which in no way connote prosperity. Thus, in the Territory of New Guinea, revenue rose in the year 1937–8 as a result of imports made to replace goods destroyed in the eruption at Rabaul. One of the few territories with an effective insurance against these fluctuations is the Gilbert and Ellice Islands Colony, where the British Phosphate Commissioners pay a contribution to balance the budget, in return for exemptions from ordinary taxation. Hawaii is in the exceptional position of deriving none of its revenue from customs. The raising of customs duties is a prerogative of the federal government. The principal source of revenue for the territory is a tax on real and personal property—a form of impost which reflects the administrative maturity of the territory, for it demands elaborate machinery for its assessment and adequate rights of appeal. Most territories receive, either regularly or as occasion demands, grants from their

metropolitan country. During the last ten years or so these have tended to increase.

Detailed comparisons of expenditure are apt to be misleading. In the case of the smaller territories, for example, the employment of a single doctor and the maintenance of a small hospital—an irreducible minimum, if there are Europeans in the service of the administration—will, if reduced to a percentage basis, give the appearance of favourable comparison with medical services in larger territories. Or, again, the fact that the Territory of Hawaii spends about half its income on education is not a suitable basis for comparison with the figures for other territories till allowance has been made for the complex division of function between federal, territorial and county authorities. Some significant facts, however, do emerge. Owing to the small size of territorial units administration absorbs an unusually large proportion of available funds.

Expenditure on Administration in the Pacific and in Africa (as percentage of total expenditure)

Territory	Year	Percentage	Territory	Year	Percentage
Fiji	1937	45	Nigeria ..	1936–7	29
Gilbert and Ellice Is. Colony	1936–7	46	Sierra Leone ..	1936–7	33
British Solomon Is. Protectorate	1936–7	48	Nyasaland ..	1936–7	36
Tonga	1937–8	54	Gambia ..	1936–7	51

The high figure for the Gambia, which like the Pacific territories is small in size and resources, emphasizes the relationship between the size of administrative units and expenditure on administration. Based on Colonial Office, *An Economic Survey of the Colonial Empire* (*1937*), pp. 511, 523-4, 529-30, 535 (London, 1940).

Thus, though some Pacific island territories are not particularly poor in comparison with colonial territories elsewhere—e.g., Fiji had a revenue of £4 0s. 7d. per head of population in 1937, compared with £1 4s. 9d. in Ceylon, £1 0s. 0d. in Kenya, and 7s. 6d. in the Gold Coast—there is comparatively little left for social services. Fiji, in fact, was spending 21% of its revenue for these purposes at that time compared with the 22% of the relatively much poorer Kenya. In the smaller and more backward territories the difference

is most marked. In the British Solomon Islands Protectorate, for example, there has been nothing at all to spare for education.

LOCAL GOVERNMENT

Owing to the small size of administrative areas in the Pacific islands, local government is comparatively undeveloped. Functions which would be delegated in more populous territories to town and county administrations are retained by the central government. Hawaii, however, is in this respect, as in others, an exception owing to its greater wealth and populousness. It has a well-developed system of local government. Elsewhere, the larger towns generally have some form of separate municipal administration; and, in some areas, there are road boards and other *ad hoc* bodies with limited powers. The local governing bodies most characteristic of the Pacific islands, however, are those which have been formed to give the native peoples some degree of autonomy in matters primarily of concern to them. Village councils, island councils, or similar organizations exist in many of the more advanced parts of the Pacific.

Municipal and County Administration

Honolulu, as the only city in the Pacific islands, stands alone in having a highly organized municipal government. In form it is a government of the 'city and county' of Honolulu and includes the whole of the island of Oahu within its jurisdiction. But in practice the major part of its work lies in the city of Honolulu, where the majority of the population of the island is concentrated. It is controlled by a mayor, who is required to devote his whole time to municipal administration, and a board of supervisors. Both mayor and supervisors, together with a number of the higher executive officials, are directly elected by the people every two years. Its functions include the maintenance of school buildings, roads, public parks, etc., and the provision of public services, such as water supply. In 1929, when a study was made of its working, its staff numbered over 1,000 and its annual expenditure over $10,000,000—i.e., roughly the same as the expenditure at that time of the territorial government.

The county administration, which covers the remainder of the Hawaiian islands, is generally similar in structure and functions;

but the revenue of the counties in no case approaches that of Honolulu.

Both Noumea and Papeete are administered by a mayor and municipal council; and Suva has a town board, with fairly extensive functions (vol. III, p. 180). The smaller settlements in New Caledonia and the Society islands have municipal commissions, but these possess only very limited powers. In Fiji, also, a form of local administration for the smaller towns has been evolved—the township board. The powers of these bodies differ somewhat from one another, but they are never extensive; several of them are concerned solely with sanitary matters.

In the Japanese mandated islands, municipal governments, dealing with health matters, the maintenance of order, etc., have been set up in settlements with a predominantly Japanese population, such, for example, as Ponape town. These have a mayor and town assembly elected every four years by male citizens.

Native Administration

In nearly all parts of the Pacific islands governments have had to make special provision for dealing with the native communities. Both in political and economic matters, native peoples have had great difficulty in adapting themselves to Western forms of thought and behaviour, which have very frequently differed widely from their own. The action which governments have taken has differed very greatly from territory to territory, depending both upon the state of native society and upon the broad aims of the administration.

In Polynesia and Micronesia, chieftainship, with a resulting concentration of power, was highly developed when Europeans first came to the Pacific. The activities of traders, missionaries, and others greatly increased the potential power which an able chief could exercise. Thus, there came into being the highly organized kingdoms of Hawaii, Tahiti, and Tonga (Chapters IX, X). In Samoa and in Fiji—on the eastern verge of Melanesia—political organization was equally complex, though the native governments were less effective. And in other areas, such as the Gilbert islands, the power and resources of many chiefs greatly increased, even though their territories remained confined to a single island. In most of Melanesia, on the contrary, native communities were small, and power was diffused. Generally, they did not begin to be modified by European contacts until much later. Often, as with the labour

trade (Chapter X, pp. 300–7), European activity took a form which was purely destructive. Native institutions lost much of their former cohesion, and the power of native leaders became even less than before.

Where centralized native governments already existed, these have generally been used by the present authorities, for they provide a simple channel of communication between government and people and make possible considerable economy in the employment of European staff. In Tahiti, it is true, the native monarchy was allowed by the French gradually to wither away from lack of any real function; and, in Hawaii, the native people were already outnumbered and submerged in a community of basically Western type when America annexed the islands. In Tonga, by contrast, Great Britain, as the protecting Power, left the native authorities in complete control of the central administration of the islands. The general practice has been midway between these two extremes. Native policy has not been confined as it has been perforce in Hawaii to projects, such as the Hawaiian Homesteads Act (vol. II, pp. 355–6), for assisting the natives to assimilate themselves to Western society as painlessly as possible; nor has it aimed at giving them complete self-government. It has been concerned with the creation of semi-autonomous systems of local government.

Such an aim can be achieved most simply where there is no considerable non-native population. In the main groups of the Gilbert and Ellice Islands Colony, for example, European officers are stationed only at two district headquarters in the Gilbert islands and one in the Ellice islands.* The routine work of local administration is left to the 'native governments', which exist on every island with an indigenous population. Each government consists of a native magistrate, appointed by the central administration, a council of elders (*kaubure*), elected by the people, and a scribe, who keeps the records, collects revenue, and acts as postmaster.

The village committees in the Tokelau group and the island councils in the Cook islands are very similarly organized and exercise very similar powers. A much feebler, though in some respects similar, form of local government has been evolved in French Oceania. The French have failed to take full advantage of the political institutions which the native peoples possessed, and have somewhat arbitrarily divided the colony into about 70 districts.

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* The administrative headquarters of the colony are on the isolated Ocean island; there, of course, a larger European staff is employed.

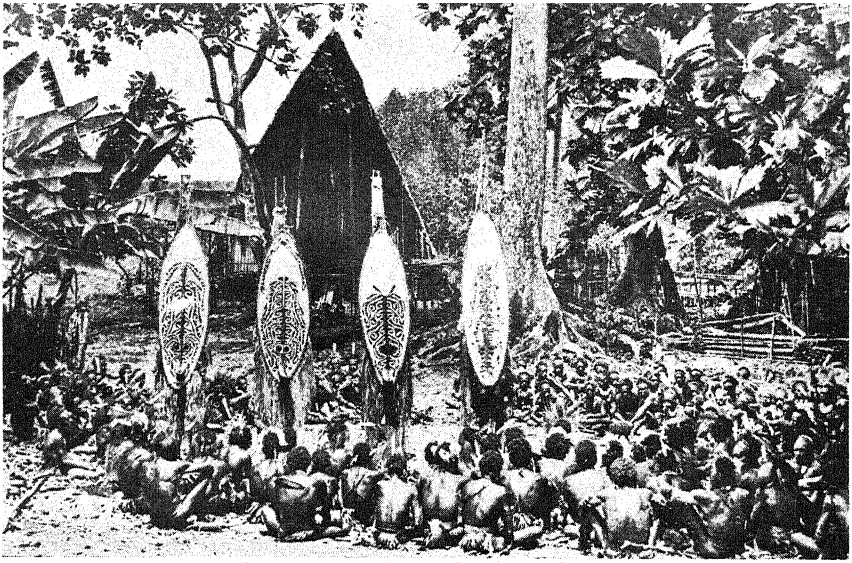

Plate 147. A pagan religious ceremony at Urama, Papua
The four masks (*kaiva-kuku*) play a part in initiation rites; no woman or young child is allowed to look at them.

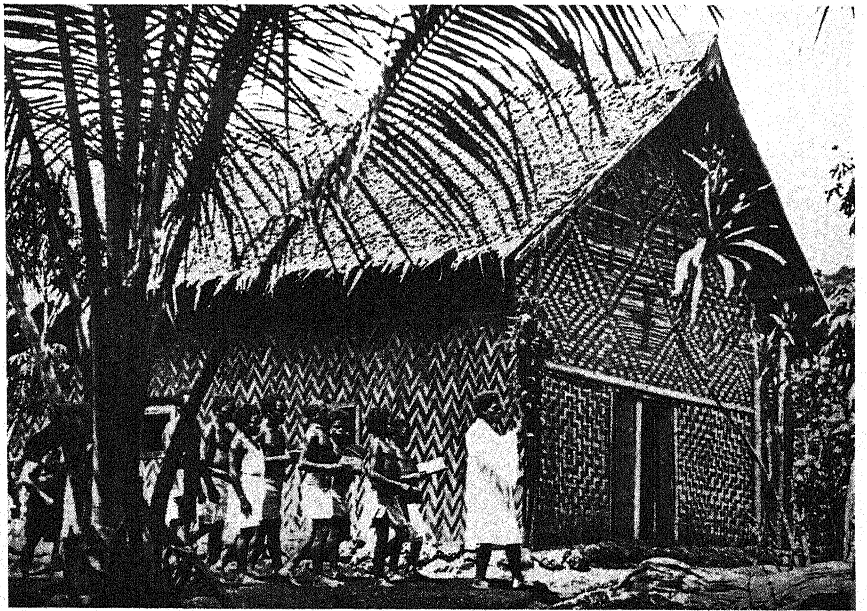

Plate 148. All Saints' Day procession at a Melanesian Mission church in the Solomon islands
A native teacher bearing a floral cross leads the procession; he is followed by the

Plate 149. Tax collecting, Malaita, Solomon islands
The villagers file between lines of native constables to pay their head-tax to the District Officer seated on the verandah.

Plate 150. The hospital at Saipan

Of these 17 are in Tahiti, 4 in Moorea, 10 in the Marquesas, 30 in the Tuamotu administration, 4 in the Gambier administration, and 3 in the Austral islands. In the Tuamotu administration up to four islands are, in some instances, combined in one district. Each council consists of about 5 members elected by the people; in practice, the chairman is usually a native chief. The councils see that the villages are kept clean, supervise co-operative marketing in some areas, and—with more or less effectiveness—organize the communal activities of the people generally. They have not, however, been given any powers of raising funds for their work. In the Japanese mandated islands, native officials owe their position entirely to appointment by the government; but, in practice, the traditional leaders are generally chosen. There are several ranks of chiefs and headmen, with powers varying in different parts of the territory. They are concerned mainly with the publication of government laws and regulations to their people, with the collection of taxes, and with keeping the government informed of local conditions. Generally, their jurisdiction does not extend beyond their own village. There is no provision for the recognition of native councils.

Much more highly organized systems of native administration exist in Fiji and Western Samoa. Their elaborateness results from the complexity both of the native political systems upon which they are based and of the present economic and social structures of the two territories. The longer established system is that of Fiji, which was organized by the first Governor of the colony, Sir Arthur Gordon, nearly seventy years ago (vol. III, pp. 180–4). In each village there is a headman. Groups of villages form districts, of which there are 153 in the whole colony. Where possible their boundaries are based on the traditional tribal divisions. Each district is presided over by a district headman (*Mbuli*), who has associated with him a council of chiefs and village headmen. The districts are formed, in turn, into nineteen provinces, generally with a European Provincial Commissioner and a Native Assistant Commissioner (or *Roko Tui*) as its chief administrative officers. Each province has, in addition, a provincial council. All these bodies have considerable authority in their own spheres. And they have their judicial equivalents in the native courts (p. 475). There is provision also, however, for a more direct association between the native authorities and the central government. The *Roko Tui*, a number of *Mbuli* elected by the provincial councils, and representatives of the native magistrates and medical practitioners, form a Great Council of Chiefs (*Mbose ni*

Turanga), which advises the Governor on general matters of concern to the Fijian people. The Great Council also proposes a panel of names from which the Governor selects the Fijian members of the Legislative Council. In addition, there is a Native Regulations Board, which legislates on specifically native matters.

Though developed independently, the native administrative system of Western Samoa is in some respects markedly similar. Each village has a council, presided over by a village mayor (*pulenu'u*). The villages are grouped into districts based on the ancient political divisions. In each district there is a council, composed of chiefs, *pulenu'u* of the constituent villages, and others, and presided over by a *Faipule* (deputy). The *Faipule* in turn attend a general council for the whole territory, the *Fono* of *Faipule*, corresponding to the Fijian Great Council of Chiefs. In detail, however, the Samoan system works very differently. In Fiji, nearly all office-holders are appointed from above, and the privileged circles from which it is thought legitimate to choose holders of the major offices are generally very small. In the Fijian mind, too, this hierarchy of rank and privilege is not limited to native society. The Governor occupies the position once held by Thakombau, the King of Fiji, and he receives from the *Roko Tui* the same kind of respect which they receive from their inferiors, the *Mbuli*. In Samoa, on the other hand, many offices are filled by election. The *pulenu'u*, for example, are chosen by members of the village councils, and the *Faipule* are elected for a three-year term by the male Samoans of each district. The consequences of these differences in the working of the two systems have been very marked. In Fiji there has been very little friction between the government and the native authorities, whereas in Samoa the factiousness which had so long existed in native society (Chapter X, pp. 321–2) has been extended to relations between native leaders and the government.

In Melanesia (apart from Fjji) native administration has presented very different problems. In several territories there are still large areas which have never been subjected to any form of government control. In the Mandated Territory of New Guinea, with a total area of 93,000 sq. miles, only 39,000 sq. miles was under complete control and another 23,000 sq. miles under partial control or in contact with government patrols in 1940. Since that time the war with Japan has produced a disastrous setback. Similarly in Papua, although the whole territory has been explored by government parties, a large area has never been brought under control. Parts of the

New Hebrides also remain uncontrolled, while over much of that territory governmental influence is of a most exiguous kind. In the British Solomon Islands Protectorate—affected like New Guinea by Japanese invasion in 1942—the last of the major islands was brought under full control only in 1941.

The process of peaceful penetration of regions where the government's jurisdiction has remained unrecognized has no counterpart in the present-day affairs of Polynesia; and even in Fiji it was completed nearly sixty years ago. In Papua and the Territory of New Guinea it has continued to form a major work of administrative officers. Careful methods of procedure have been evolved. They reproduce the techniques of missionary bodies rather than those of normal government activity. The methods employed in the Territory of New Guinea well illustrate this. A base camp is first established in the area to be brought under control by an administrative officer and a party of native constables. Gifts are distributed, and trading is carried on with visiting natives. If no hostility is shown during the first few days, the friendly intention of the natives is assumed. Patrolling of the villages then begins. Further gifts are distributed, and the officer explains the purposes and the prohibitions of the government. The people are instructed to build a rest-house for the use of future patrols and of other white visitors; and, in return, seeds and cuttings of European vegetables and fruit are distributed. On the first patrol it is usually possible to negotiate truces between hostile villages in the area and to select youths for training as medical orderlies. At the end of a period of about three months, the patrol officer leaves the area. Often his work is consolidated by stationing parties of carefully chosen native police at suitable points in the area. These men settle down with their wives and families, make gardens, and act as unobtrusive teachers of the local people—showing them how to grow new crops and explaining to them government regulations.

Even in the areas under full control, administration is generally very different from that in Polynesia. In New Guinea, the Solomons, the New Hebrides, and New Caledonia the devolution of authority upon the natives themselves has not proceeded very far. This is due—at least in New Guinea and the Solomons, where there has been a strong desire to create effective native authorities—both to the limited capacity, as yet, of native officials for administrative responsibility and to their lack of authority among their own people. Even where traditional leaders exercising real authority over their

people have been found, it has very often been impossible to confer government office upon them owing to their complete lack of understanding of the aims of the government; native headmen, village constables, medical orderlies, and other officials have had to be chosen from those who have been away from their communities to work for the white man. Thus it has become possible to make government policy bear upon the everyday activities of the people; but it has remained impossible to bring native social structure into as close an organic relationship with that of the central government as has been done in Fiji and in many parts of Polynesia.

LAW AND JUSTICE

In most Pacific island territories the main body of law is that of the country responsible for the administration, modified in varying degrees to suit local conditions. The basic law in Fiji, for example, as in all British colonies, is the common law and equity, and the statutes of general application which were in force in England at the time the administration was created. Later additions and modifications have been made to some extent by Orders in Council and other imperial enactments, but mainly by Ordinances of the local Legislative Council. In the Japanese mandated islands the law is that of the Japanese Empire. In the autonomous Kingdom of Tonga it is the code enacted by the Tongan parliament. In the French colonies all French citizens, whether European or non-European, are subject to the *justice française* and their actions are thus regulated by the French codes, modified to suit local needs. The situation in American territories is slightly more complicated, owing to the federal structure of American government. The main body of private law in the United States is state law, not federal law; but this is in all cases based on English common law. In Hawaii, English common law, as modified by local statute, precedent or usage, was adopted by the royal government in 1892. It was retained after annexation. Later additions and modifications have mainly been made by the territorial legislature, but some have been made by federal legislation. In Guam, a mixture of Filipino and Spanish law was retained till 1933. New codes were introduced in that year, however, based on the law of California.

One point upon which great differences exist is in the extent to which native customary law is recognized in matters affecting natives. In Fiji this was made the basis of a code of native regulations in

the early years of the colony. This code has been kept under continuous review by a board, of whose four members three are at present (1944) Fijians; and modifications have been made in accordance with changes in the Fijian way of life. In the Gilbert and Ellice Islands Colony native law has similarly been codified. Elsewhere in British Polynesian territories it remains generally uncodified, but it is acted upon to a large extent in the courts. Special attention is generally paid to it in cases relating to land tenure or to succession to property or titles. In French Oceania the position of native law differs in the various administrative areas. It is of the greatest importance in the Leeward group of the Society islands, where a code based on the actual usage of the native courts was published in 1917. Where natives alone are concerned, the code applies in both criminal and civil matters; and it is interpreted and applied by native judges. The principal restrictions upon it are that modifications can only be made with the consent of the Governor of the colony, that judges are appointed by the Governor, and that judgments require the approval of the local administrator. The laws of Rurutu and Rimatara have similarly been codified and published. In Tahiti, with its much larger non-native population, and in the Marquesas, where the native people are now only a remnant, native laws are of less importance in the administration of justice.

In most of Melanesia the acceptance by governments of native law has presented greater difficulties. Owing to the multiplicity of languages and cultures, Europeans have not gained so full a knowledge of it as they have of Polynesian law; and the practical application of it in courts of law has to a large extent proved beyond the powers of most officers of justice. Further, a considerable proportion of Melanesian customs has been regarded by Europeans as repugnant to natural law and justice. In British territories, an attempt is often made to take native custom into account in matters such as land tenure, succession, marriage and divorce. In New Caledonia, on the other hand, native law has no standing in European courts, but within native reservations the natives may apply it so far as they wish.

The judicial systems of the Pacific island territories conform fairly consistently to a general pattern. In all the major territories there is a high court—generally known either as a High or a Supreme Court—which hears appeals from the inferior courts and usually has an original jurisdiction of its own. From many of these courts a

further right of appeal lies to some tribunal outside the islands. From the High Courts of Western Samoa and the Cook islands, for example, appeal lies to the Supreme Court of New Zealand; and from the High Commissioner's Courts of the Gilbert and Ellice Islands Colony and the British Solomon Islands Protectorate it lies to the Supreme Court of Fiji. In Hawaii, the judicial structure is made more complex by the division of jurisdiction between federal and territorial courts. There is a United States District Court, at Honolulu, administering federal law, in addition to the territorial courts of the islands. Similarly in the Condominium of the New Hebrides jurisdiction is divided. The Condominium Joint Court has jurisdiction in respect of land claims, the liquor traffic, labour recruiting, criminal offences by natives against non-natives, and a number of other specified matters; in other matters jurisdiction lies with the British or the French National Courts.

In most territories the high court is presided over by a professional lawyer, who devotes his whole time to judicial work. This, however, is not always so. In Guam, for example, the Court of Appeals is composed of a presiding justice, who is a naval officer with legal experience, and four associate justices. In other territories, such as the Gilbert and Ellice Islands Colony, Nauru and American Samoa, it is usual for the executive head of the government to act also as chief judicial officer.

Judicial organization below the high court differs widely between territory and territory, in general accordance with political development and population. Hawaii is divided into five judicial circuits, in each of which there is a Circuit Court, with civil and criminal jurisdiction. The judges of these courts are appointed in the same way as those of the Supreme Court—i.e., by the President of the United States—and they are required to have the same qualifications. For the trial of minor offences, District Courts have been set up throughout the territory, presided over by district magistrates, whose status and function correspond to those of justices of ths peace in the United States. In addition, there are special courts dealing with land matters, tax appeals and juvenile offenders. Elsewhere, inferior courts are most frequently presided over by men who combine judicial with other duties. The judicial organization of Fiji may be taken as an example. Below the Supreme Court of the colony there are Magistrates' Courts. These are held in Suva and some of the more important industrial centres by

a Stipendiary Magistrate, with legal qualifications, but elsewhere by an administrative officer. Below the Magistrates' Courts there are native courts, with jurisdiction over natives only. The basic organization in French Oceania is not very dissimilar. At Papeete, there is, in addition to the High Court, a Court of First Instance, concerned with civil matters, and a Commerical Court. The judge of the Court of First Instance also holds a commission as justice of the peace with extended jurisdiction. At Raiatea there is stationed another justice of the peace with extended jurisdiction, who maintains a court for the Leeward islands. In addition, administrative officers in other parts of the colony, including the Marquesas, hold ordinary commissions as justices of the peace. In the smaller dependencies organization is much simpler. In the Gilbert and Ellice Islands Colony and the British Solomon Islands Protectorate, for example, there is only one court, with the exception of native courts. This is the High Commissioner's Court. A greater flexibility is given to the system, however, by varying its jurisdiction according to the status of the officer presiding over it at any particular time. In Norfolk island a similar device has been used, the single court possessing a 'full' and a 'lower' jurisdiction.

One of the most characteristic features of colonial judiciaries is the absence, or very restricted use, of the jury system. This is due to the small proportion of the population which, in the view of the rulers, is qualified to give fair and unbiassed decisions. In this, as in so much else, Hawaii stands somewhat apart. Juries were used in the courts of the Hawaiian Kingdom, and they retain their full importance today. In Fiji criminal cases are heard in the Supreme Court by a judge and jury when the accused is a European; in other cases the judge sits alone or with assessors. The use of assessors is very general in the Pacific, for it enables the judge to obtain advice without completely binding him to abide by it. It is found in territories as various as Fiji, Western Samoa, New Caledonia, and Tonga.

One of the most widespread features of Pacific islands judicial systems is the special provision for associating the native people with the administration of justice. The varying methods employed provide a significant indication of native political organization and of the colonial policy of the governing authorities. In the more advanced territories they frequently take part in the work of the supreme courts, without, however, having decisive power placed in their hands. Thus, in Western Samoa a native Associate Justice

sits with the Chief Justice during proceedings in the High Court; and in the Leeward group of the Society islands native judges hold a position of considerable responsibility, as has been noted. A somewhat unusual division of powers between Europeans and natives has existed in recent years in Guam. The Court of Appeals, with an American presiding justice and two American and two Chamorro associate justices, conforms to a well-established pattern. Below this court, however, come the Island Court and the Justice Court, which between them deal with all major civil and criminal matters; each is presided over by a Chamorro judge with legal training. Petty offences are dealt with in the Police Court, which is presided over by an American officer; and appeal lies from his decision to the courts of his Chamorro colleagues.

Much more usually, native judicial officers sit in courts with jurisdiction over natives alone; and appeal from their decision normally lies to a court with a European judge. Thus, in Western Samoa district courts, presided over by native judges (*Fa'amasino*), deal with civil and criminal offences involving natives where the maximum penalties are below certain limits; and the *pulenu'u* (village mayors) have judicial powers in respect of breaches of local regulations. The native courts of Fiji and the Gilbert and Ellice islands have basically similar structures and functions, though in practice they are more fully developed than the courts of Western Samoa. There is a striking contrast between these institutions and the native courts which have recently been established in the British Solomon Islands Protectorate. Owing to the native social structure of the Solomons, which is in this respect typical of most of western Melanesia, the appointment of native judges would have found no sanction in local custom. The government has therefore constituted courts, in the various administrative sub-districts (or headman areas), composed of the native headman and a panel of elders—numbering perhaps twenty or thirty.

SOCIAL SERVICES

Medical Services

An outline of health conditions and of medical organization in the Pacific islands has been given in Chapter VIII. Here it is intended only to note the special problems of organization which arise in most territories from the dispersion of the population over many scattered islands and from the generally low level of income. Only

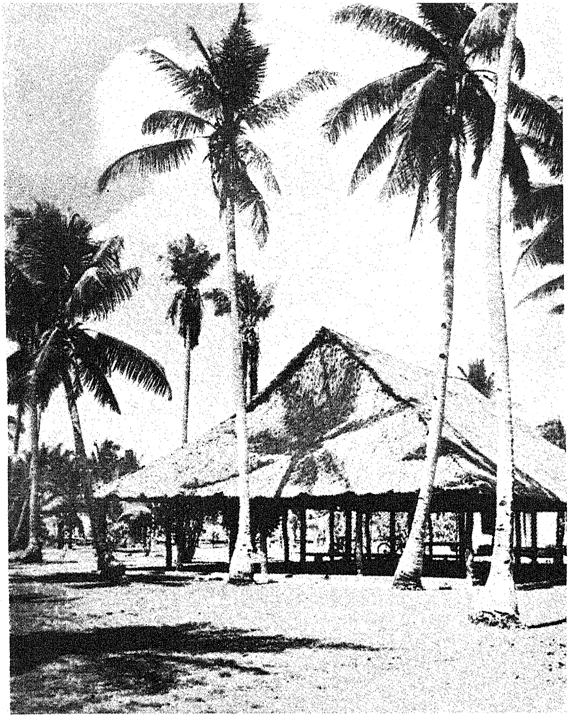

Plate 151. Court house, Nauru
The chiefs of Nauru administer justice, as magistrates of the District Court, in buildings such as this.

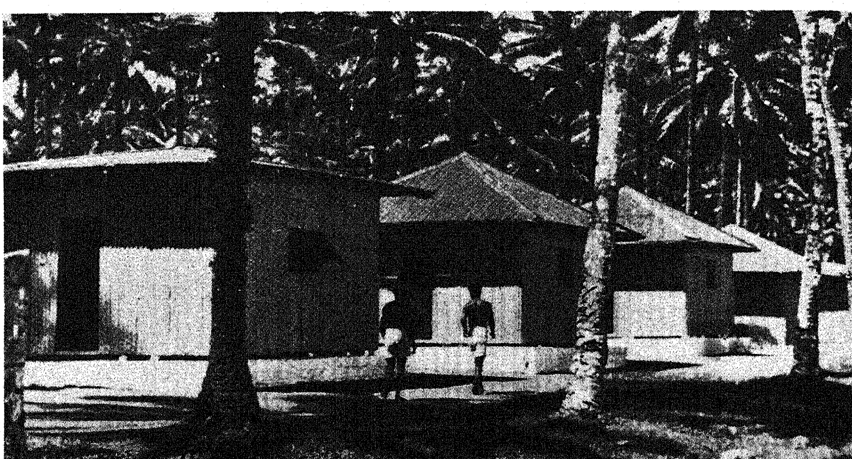

Plate 152. Labourers' quarters on a plantation in the Solomon islands
The buildings are of corrugated iron and are intended each to accommodate

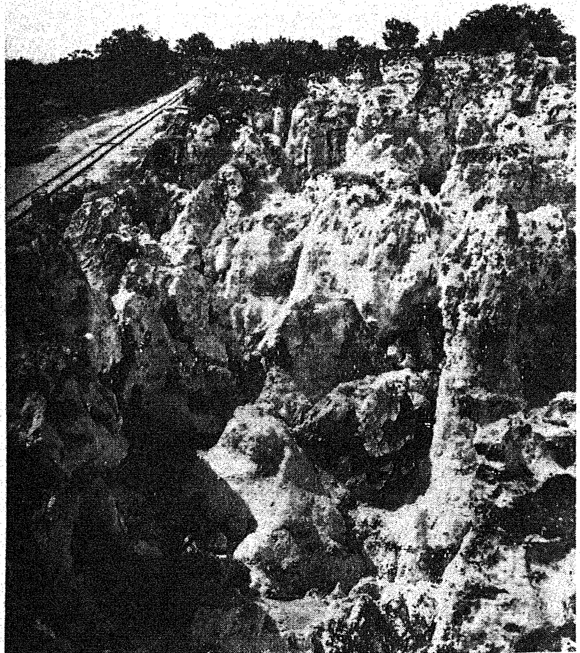

Plate 153. Worked-out phosphate land, Nauru
This view shows the coral pinnacles which remain after the phosphate has been removed.

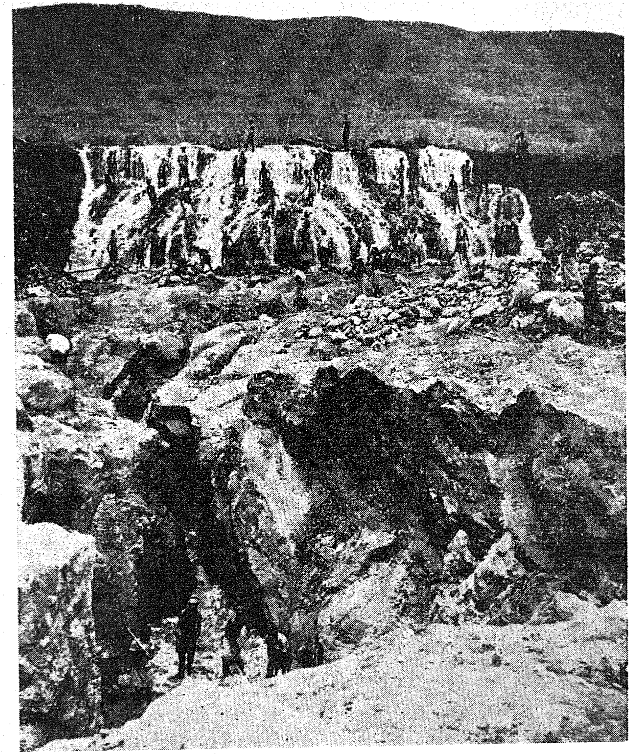

Plate 154. Gold working, Morobe goldfield, New Guinea
Showing the sluicing of gold. Water is running down the wash face. The coarse stones are picked out by native labourers, and the finer material is carried down the channel to the sluice box.

in the Territory of Hawaii and in a few of the larger towns, such as Suva, are there conditions to attract private medical practitioners. Over nearly the whole of the Pacific, therefore, the full burden of providing medical services has fallen on governments or on philanthropic organizations, such as missions.

From the earliest period of European settlement in the Pacific islands, medical work has formed an important part of the work of missions. In former times this work was usually of a very simple kind, performed by men with little or no formal training. At present missions are most active in the medical field in the more backward territories, where governments are unable to provide an adequate service. In such areas, many missions include qualified doctors among their members and maintain hospitals, while nearly all missionaries have received some training in first-aid and elementary medicine.

All but the very smallest of Pacific island administrations maintain some form of medical organization. Medical attention and simple hospital facilities are regarded as necessary for government officers themselves and for other Europeans in the region. Round this core of necessity, medical services for natives are gradually built up as funds and opportunities permit. In the American territories of Hawaii, Guam and American Samoa a very high standard has been reached. Hawaii, owing to its wealth and larger population, has medical facilities up to the standard of most parts of the United States, while Guam and American Samoa are exceptionally well provided for, owing to the presence of naval hospitals and medical personnel. In British territories an attempt is being made to provide an adequate service, despite restricted funds, by the increasing employment of native medical practitioners or medical orderlies. The Central Medical School at Suva, Fiji, has been expanded in recent years and its course of training increased from three years to four years with this end in view (vol. III, p. 188); considerable further expansion is planned for the years following the present war. It regularly receives students from all the territories administered by Great Britain and New Zealand. (It also has the support of the American authorities; in 1940 there was a student from American Samoa in the school, and enquiries had been made regarding admission for students from Guam.) The Australian government has sent Nauruans to the school, but in New Guinea it has preferred to retain for the present its own schemes for more elementary training of medical orderlies. Despite the shortcomings

of the pre-vocational training which most native students have received, their work is often of a very high order.

The position of European medical officers is, however, no less important. In some of the more advanced territories, such as Fiji, they are being increasingly concentrated in the main centres, where the larger hospitals are established. With improvement in transport arrangements it is possible for most major cases to be referred to them by their native colleagues in the rural areas. When present plans for the employment of air ambulances mature, the possibilities of much further centralization will be opened up. In the more backward areas, however, and where there are no natives with adequate training, the European medical officer still has much travelling to do, making large numbers of simple diagnoses and persuading the people of the efficacy of Western medicine. Such, for example, are the medical patrols in the Territory of New Guinea (vol. IV), which in 1938 gave a cursory physical examination to over 200,000 natives. Or, again, in the same category are the visits by medical officers in New Caledonia to the native tribes within their districts at intervals of six months or less.

In the Pacific islands, as in other colonial areas, large-scale campaigns against various endemic diseases and in favour of improved housing and sanitation have often been undertaken. Amongst the most striking have been those against yaws and hookworm undertaken by the International Health Division of the Rockefeller Foundation, in conjunction with the governments of British Pacific island territories. These, however, have been regarded—especially by their organiser, Dr. S. M. Lambert, of the Rockefeller Foundation—as primarily the first stage in converting the people to a faith in modern medicine and towards the establishment of regular medical contact with them. They are the counterpart in the field of medical science of the New Guinea administrative patrols (p. 471); they are not an alternative to the less spectacular daily work of medical practitioners, European or native.

Education

Government activity in education in Pacific territories varies from almost nil in certain areas to the exercise of major responsibility in others. The difference can largely be explained in historical terms. Everywhere, the first schools were founded by missionary bodies. In Polynesian areas, such as Hawaii, where effective native

governments were formed, the control of education tended to pass early into official hands, for the governments themselves were generally willing to adopt a policy satisfactory to the missions. Elsewhere, government action developed only slowly. It has most frequently taken the form at first of monetary grants to mission and other private schools and of special provision for the training of selected groups of natives for various forms of public office—whether as magistrates or clerks, medical practitioners or dispensers, school teachers or agricultural instructors. Social and economic development in the more advanced areas has, however, created the need for a much broader interpretation of governmental responsibility, since missionary bodies have generally lacked the resources needed to provide the mass of the people with much more than an elementary knowledge of reading, writing and the scriptures.

Government control has advanced furthest in the territories administered by the United States and New Zealand, and in Tonga. Hawaii has a fully developed public school system on American lines. The government maintains nearly 200 schools, employs between 3,000 and 4,000 teachers, and provides instruction for about 90,000 pupils. In addition to the elementary, or 'grade', schools, there are junior high schools and high schools, various special schools and the territorial university. The University of Hawaii, the only university in the Pacific islands, is modelled on the state universities of the United States. It resembles them particularly in the attention which it gives, in its teaching, to special regional interests. Courses are given by its agricultural staff, for example, in the cultivation of citrus fruits and sugar. The conditions which have made possible a complete system of public education have also preserved the demand for private schools. Excluding the foreign language schools (vol. II, pp. 352–3), which satisfy a transitory need, most of the private schools provide education for the children of the relatively well-to-do Europeans. Several of them, such as Punahou School, have gained a considerable local celebrity, both from their long history and their present standards of teaching and equipment. In Guam and American Samoa and the New Zealand territories of Western Samoa and the Cook islands educational facilities are less extensive. In Guam all children attend government schools. In American Samoa and the Cook islands the majority do so, though there are also mission schools. Higher education for potential leaders is provided in American Samoa at the Feleti School, which is liberally financed from the income of an American benefaction. In the Cook

islands the New Zealand authorities have established a teacher-training college at Avarua, in Rarotonga; but, for higher education of a more general kind, young people are sent to the Maori colleges in New Zealand. A small number are sent to the Central Medical School, in Fiji. In Western Samoa a more complex division of function has been worked out between missions and government. Village schools, for children between the ages of five and ten, remain under the control of the missions. Above them are district schools, fewer in number than the village schools but with a somewhat larger attendance; these, too, are frequently controlled by the missions, but their teachers are trained and paid by the government. From the district schools the more promising pupils go on to boarding schools—some controlled by the government and paying special attention to agricultural and other vocational training; and some controlled by the missions and looking towards the training of native pastors. At the apex of the educational pyramid stand the government Teachers' Training College and the mission theological colleges. In Tonga, as in the Cook islands, the majority of primary schools are controlled by the government, though a large minority remain under the control of the churches. Secondary education is unusually well developed. The government college, at Nuku'alofa, had nearly 200 students in 1940, besides conducting evening classes for non-members; and there are also several secondary schools controlled by the churches.

The territories administered by the British Colonial Office show a greater variety in educational organization. The highest stage of development has been reached in Fiji. Primary education is provided for Fijians mainly in the village schools and in a number of central schools, most of which are controlled by the people themselves and assisted financially by the government, if certain standards are attained. In addition, there are a number of government boarding schools, which provide a combined general and vocational education. Primary education for Indians is given mainly in schools controlled by local Indian committees, Indian religious societies, or Christian missions, with government financial assistance, though the government has been forced in some areas to establish schools itself. Secondary and vocational education has been, on the contrary, partly a government responsibility from the beginning. There are government grammar schools for Fijians, Indians and Europeans; and both the government and the missionary bodies provide training for school-teaching and for trade and agriculture. The government

Central Medical School and the Central Nursing School (vol. III, p. 188) receive pupils not only from Fiji but from many other Pacific territories.

In the Gilbert and Ellice Islands Colony the village schools still remain under mission control; but government grants are made to them, and the government has established two boys' boarding schools—one for the Gilbert islands and Ocean island, at Tarawa, and one for the Ellice islands, at Vaitupu. In the British Solomon Islands Protectorate, however, as in the Anglo-French condominium of the New Hebrides, the governments take almost no part in educational work. The schools are nearly all under mission control and, since government financial help is not available, the standard of teaching and equipment is generally very low.

In the Australian-administered areas of Papua and the Mandated Territory of New Guinea, the governments have not been quite so inactive; but a broadly similar situation exists. In the more advanced and unusually wealthy island of Nauru, on the contrary, an effective government system of education has been established. Nauruans themselves now take an important part in the formulation of educational policy. Secondary schools have been established for both boys and girls, and special attention is given to vocational training.

French policy in New Caledonia and in French Oceania has been generally similar to that of Great Britain. There are government primary schools in all the principal centres in New Caledonia, and also at Papeete and in other parts of Tahiti; and at Noumea secondary education is provided by the College La Pérouse. Nearly all these schools, however, are intended primarily for the children of French residents. Native education is left in both colonies mainly to the missions.

The fundamental problem of education in the Pacific islands, in regard both to natives and to non-European immigrants, is that of the extent to which pupils should be encouraged to adopt European modes of thought and behaviour. It is a problem which concerns alike the organization of the schools, the nature of the curriculum, and the medium of instruction.

In American territories, the policy of 'Americanization', which has been adopted with such effect in the United States, has until recently been rigorously applied. Thus, in Hawaii, government schools are open to members of all racial groups; English is the medium of instruction; and emphasis is laid upon the teaching of

American history and institutions. Policy in Guam and in American Samoa has been similar. Recently, however, under the influence of current educational theory, there has been some attempt to adapt educational practice to the conditions of life of the pupils, and thus uniformity has begun to break down. Japanese policy also has aimed at assimilation; and though separate schools have been established for the various racial groups, special stress has been laid upon the teaching of the Japanese language and Japanese ethics.

French colonial policy is traditionally associated with the conception of assimilation; and, especially in French Oceania, it formerly constituted the basis of educational policy in the Pacific. More recently, however, the emphasis has shifted to the preservation of native institutions. There are separate schools for natives and non-natives; and, though the French language is very widely taught, it forms the medium of instruction only in the more advanced schools attended by natives.

The general aim of Great Britain, Australia and New Zealand of preserving native institutions so as to prevent the growth of a class of *déracinés* has found a very full outlet in educational practice. In both government and mission schools teaching in the lower classes is nearly always in the vernacular, or, in certain instances, in another native language adopted as a *lingua franca*. English is introduced only gradually as a subject and is usually adopted as the medium of instruction only in secondary schools and in the colleges training men and women for professional work. One hindrance to the full effectiveness of the British policy has been the lack of text-books written either in native languages or with attention to the conditions of the Pacific islands. This difficulty cannot be completely overcome, owing to the diversity of languages in the Melanesian area and to the small population of many communities. For the major island groups, however, there is now a considerable body of school-books—including grammars, dictionaries, collections of local legends, and translations of Western classics. In some instances, text-books of local history or geography written (in English) for island secondary schools are of as high a standard as many of those to be found in the schools of England or America.

Religious Organizations

Nearly 150 years have passed since the foundation of the first Christian missions in the Pacific islands. In the Eastern Pacific

most of the native peoples have been professing Christians for over a century; and in the Western Pacific the majority of the natives have by now accepted Christianity in all areas except New Guinea. The missionary bodies now regard their work of proselytizing as lying mainly in New Guinea and among the Asiatic populations of Hawaii, Fiji, and other areas. Elsewhere missionary societies and churches are concerned with deepening popular understanding of Christian teaching and with educational and medical work.

The major Protestant bodies have maintained a general understanding as to the division of the field between them. In some instances a whole group has been left to one denomination. Thus Fiji was evangelized by the Wesleyan Methodists, and nearly all Fijian Protestants remain Methodists today. Sometimes a group of islands has been divided, as in the New Hebrides, where the Presbyterians work in the more southern islands and Anglicans of the Melanesian Mission in the northern. In still other instances agreement has been of a more narrowly local kind; in the Solomons several missions work on some of the major islands, but restrict themselves to different tribal groups or different districts.

The Roman Catholic Church has not regarded the presence of a Protestant mission in an area as a reason for keeping out. It has, however, in recent years sometimes co-operated with Protestant bodies in practical matters, such as medical work or education. The Pacific islands have been organized by the Pope into about twenty vicariates apostolic; and these have been entrusted to a number of different missionary orders. Each vicariate is under the control of a resident bishop.

In Hawaii, the American Board of Commissioners for Foreign Missions, which had undertaken the evangelization of the islands, took the first steps towards relaxing its control as early as 1848. About fifteen years later it withdrew completely, so as to give the Hawaiian church complete administrative independence. The Hawaiian Evangelical Association, which was formed to assume control, soon became itself an active missionary body in other parts of the Pacific. In Tonga, the King and other leaders severed their connection with the Australian Wesleyan authorities and formed a new Free Church in 1885. At the present time, the majority of the people are members of the Free Wesleyan Church and most of the remainder of the Free Church (a dissident body also maintaining Methodist doctrine and forms of church government), Elsewhere, religious bodies are nearly all in some degree subject to

external control. In some of the more advanced areas this control is comparatively slight. In Samoa, for example, both the Methodist and London Missionary Society (Congregationalist) churches are financially independent. They pay the salaries and expenses of both their European and native staff and provide the funds for all buildings and equipment. In return, they enjoy almost complete local autonmy. In areas such as the Solomons and New Guinea, on the contrary, though in ividual natives have long perfomed important work as ministers and catechists church members as a whole are not yet able to assume responsibility for mission work beyond the immediate confines of the village or district in which they live and work.

In former times most Protestant mission work in the Pacific islands was organized in England. Responsibility has now shifted to Australia and New Zealand. The churches of the two Dominions provide a large part of the necessary funds. Administrative headquarters of a majority of societies are in or near Sydney. Even the London Missionary Society, whose headquarters remain in England, has delegated considerable administrative powers to its Australia and New Zealand Committee. The Lutheran mission, which is at work in New Guinea, similarly maintains a director and an office in Australia.

The Roman Catholic missions are still much more dependent upon Europe. The highly centralized administrative system of the Roman Catholic Church has not admitted of so great a delegation of powers; and, at the same time, the Pacific Islands missions continue to draw a large proportion of their staff from European countries—especially from France.

Closely related to the factor of general control is that of organization in the mission field. There are wide differences in the degree to which different bodies favour concentration upon central stations or dispersion among the villages and also in the degree to which they are prepared to work through native staff. The Roman Catholics employ a high proportion of European priests, lay brothers, and nursing sisters—a practice which is made possible by the celibacy of the Catholic clergy and their willingness to live in poverty. Native adherents are employed mainly in minor positions, such as that of a catechist in an isolated village. A large part of the work of the missions is centred upon the head stations. The Mormons, who work in certain areas in the Eastern Pacific, including French Oceania and Samoa, have adopted a similar policy, and have

even brought their adherents to reside in special settlements—a practice which has been possible because of the small number of their followers.

A century ago Protestant missionary bodies adopted a not dissimilar policy. One of the most striking accompaniments of conversion to Christianity in many parts of Polynesia at that time was the abandonment by the converts of their former scattered habitations in favour of a new central village clustered round the mission station. And the European staff of the earlier Protestant mission stations was quite as large as that found now at Roman Catholic stations. The pioneer settlement of the London Missionary Society on Tahiti in 1797 included eighteen men and the wives of a number of them. Even thirty or forty years ago, some missions, as for example that of the Presbyterians in the New Hebrides, had at least twice as many European workers as they have today. The reasons for the change are various. On the one hand, native priests and laity are now capable of taking more of the responsibility themselves; and with the improvement of means of communication —especially by the acquisition of the motor launch—one European missionary can cover a much wider area. On the other hand, funds are less adequate than they were in the great age of Protestant missionary expansion. Money is scarcer; the cost of equipment is greater; and the expense of keeping a missionary and his family in the islands is very much heavier.

Some missions, however, have always worked towards the creation of a self-sufficient and independent native church. Foremost among these have been the London Missionary Society and the Melanesian Mission. Both have produced native ministers and catechists who have played a very considerable part in the work of the organization not only in their own homelands but in the more backward areas under their charge. Thus, Samoan Congregationalists (of the London Missionary Society) continue to do important work in New Guinea, as they have done since the first mission stations were founded there nearly 75 years ago.

THE PRESS

The first newspaper to be published in the Pacific islands was *Ka Lama Hawaii*, issued from the mission press at Lahainaluna, in Maui, in February 1834. Within a few years it was followed by others both in Hawaiian and English; and one of these, the

Polynesian, long played a prominent part in the public controversies of the Hawaiian islands. In other parts of the Pacific, regular newspapers did not begin to appear till about 1870. At that time the *Fiji Times* was first published at Levuka and served the then rapidly growing European community of Fiji. Apia, in Samoa, had a newspaper not many years later. And, by about the beginning of the present century, nearly all sizable groups of Europeans—including, for example, the settlers in the New Hebrides—had some form of local newspaper.

Several of the leading papers today have grown out of these pioneer ventures. There are now daily papers published in several island towns, including Honolulu, Suva and Noumea. The Honolulu dailies include one, *Nippu Jiji*, which is printed in both English and Japanese. In Hawaii and Fiji there are also published a number of specialist journals. In some of the smaller territories there are weekly or monthly newspapers. Periodicals in native languages are published by several governments, including those of Fiji and French Oceania, and by many missions.

BROADCASTING

In recent years radio-broadcasting has provided European settlers in the most isolated islands with a constant link with the outer world. In some areas there is also a considerable audience for radio programmes among Asiatics and natives.

The Table on p. 487 shows that the most powerful broadcasting stations in the Pacific islands at the present time are those at Honolulu. These stations cover the whole Hawaiian group and can often be heard much further afield. Their normal transmissions extend over about seventeen hours each day. Many of their programmes are taken from the American national networks. In the Western Pacific the most important station is ZJV, Suva, which is listened to in Tonga and Samoa as well as in Fiji. Like the Hawaiian stations, it is operated by private enterprise; but, under an arrangement with the Fijian government, it also broadcasts educational programmes in Fijian and Hindustani. Station 4PM, at Port Moresby, Papua, is operated under the same conditions as the commercial broadcasting stations in Australia. 'Radio Nouméa', a short-wave station of very low power, has hitherto maintained only a relatively restricted transmission schedule.

Settlers in the islands, however, can also hear regularly many

Broadcasting Stations in the Pacific Islands, 1944

Call-sign	Location	Frequency and wavelength kc/s. (m.)	Aerial input power, watts
KGMB	Honolulu ..	590 (508.5)	5,000
KGU	Honolulu ..	760 (394.7)	2,500
KTOH	Lihue, Kauai ..	1,490 (201.3)	250
KHBC	Hilo, Hawaii ..	1,230 (243.9)	250
VPD2	Suva	9,535 (31.46)	400
ZJV	Suva	920 (326.1)	400
FK8AA .. .. (*Radio Nouméa*)	Noumea ..	6,122 (49.00)	20
4PM	Port Moresby..	1,360 (220.6)	100

It is proposed to increase the power of the Suva short-wave station, VPD2, to 10,000 watts, thus giving it complete coverage of the Western Pacific. Based on Bureau of the International Telecommunication Union, *List of Broadcasting Stations* (Berne, 1942; with supplement, 1944).

of the more powerful medium-wave stations in the countries bordering the Pacific and short-wave stations in other parts of the world. In particular, the major medium-wave stations on the American Pacific coast are heard regularly in Hawaii; the very powerful station 2YA, at Wellington, New Zealand, provides a fairly complete coverage of the south-western Pacific; and, similarly, KZRM, Manila, and some of the Japanese stations can be heard in the Micronesian region. Among the most important short-wave services heard in the Pacific islands are those of the British Broadcasting Corporation, from the British Empire Broadcasting Station at Daventry; of the Australian National Broadcasting Service, from its transmitters at Lyndhurst, Victoria; and of the main United States networks.

BIBLIOGRAPHICAL NOTE

There is no general study of government or of social services in the Pacific islands. Detailed information is available mainly in the annual reports and other publications of the governments of the separate territories; the more important of these are listed in the Bibliographical Notes in the regional volumes of this Handbook. The best general account of government in territories administered by Great Britain is given by Anton Bertram, *The Colonial Service* (Cambridge, 1930); a more specialized study of civil service organization is Charles Jeffries, *The Colonial Empire and its Civil Service* (Cambridge, 1938). Much factual information is contained in the semi-official *Dominions Office and Colonial Office List* (London, annually). An analysis of the finances of territories controlled by Great Britain is given

in the Colonial Office publication, *An Economic Survey of the Colonial Empire* (1937) (London, 1940). The best sources for French territories are: A. Girault, *Principes de colonisation et de législation coloniale*, 4 vols. (5th–6th edition, Paris, 1927–33); Louis Rolland and others, *Législation et finances coloniales* (Paris, 1930); P. Dareste, *Traité de droit colonial*, 2 vols. (Paris, 1931); and S. Ferdinand-Lop, *Les Possessions françaises du Pacifique* (Paris, 1933). Also useful are books of reminiscences, etc., by administrative officials. The most important are listed in the Bibliographical Note to Chapter X.

Works on particular territories often give a useful account of government and social services. The most important of these are: R. M. C. Littler, *The Governance of Hawaii: A Study in Territorial Administration* (Stanford University, 1929); F. M. Keesing, *Modern Samoa, its Government and Changing Life* (London, 1934); T. Yanaihara, *Pacific Islands under Japanese Mandate* (Shanghai, 1939); Laura Thompson, *Guam and Its People* (New York, etc., 1941); S. W. Reed, *The Making of Modern New Guinea* . . . . (Philadelphia, 1943).

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CHAPTER XV

ECONOMICS

Resources and Consumption Levels : Types of Economy : Land : Labour
Capital : Production : Trade : Currency and Banking : Bibliographical Note

In the earlier years of European penetration (Chapters IX, X) the native economic systems continued to function more or less unchanged, while European traders visited the island groups in search of sandalwood, pearls, coconut oil and other commodities which they wither procured for themselves or obtained by barter from the natives. Later, in the mid-nineteenth century, when political conditions had become more settled, individual Europeans emigrated in some numbers to the islands to grow cotton and sugar. They employed many thousands of Asiatics and Pacific islanders. Shortage of capital, labour scarcities and the irregularities of the markets for tropical products proved insuperable difficulties to many individuals, and by about 1910 a large proportion of the planations had been either abandoned or bought up by a few large firms of planters and traders. Today theprivate planter has almost disappeared and production is left in the hands of three main groups: European plantation and mining firms employing mainly indentured native labour ; formerly indentured Asiatics and their descendants, who have now established themselves as small farmers and traders in some territories ; and the native peoples who still supply most of their own needs and in addition produce an appreciable quantity of goods for export.

RESOURCES AND CONSUMPTION LEVELS

By comparison with the economic resources of the large land masses round the fringe of the Pacific basin, those of the islands are of very restricted range and quality. Minerals in economically payable amount exist only in the Western Pacific ; soils are often only poor or medium ; and, though marine resources are apparently considerable, means to exploit them on any scale have been devised in only a few instances. The proportion of the natural resources that have any human significance is dependent on such factors as the type of economy and technology of the inhabitants. This is shown by the history of some of the central equatorial islands. They were so poor in food resources as to be uninhabitable by native populations,

but they contained considerable phosphate deposits, which Europeans with their superior technique and need for fertilizers were able to exploit. On the other hand, important additions to agricultural resources have been made by introducing plants and animals of economic value. Indeed, the staple food plants of most islands—coconuts, taro, and yams—were probably all introduced and diffused through the islands by native voyagers. These voyagers also brought pigs with them. All the other livestock and many crops utilized locally or exported have been added to the island resources by European and Asiatic immigrants.

Resources vary greatly, not only between group and group but between 'high' and 'low' islands in the same areas. The low islands have been made habitable only by the introduced coconut palm, which furnishes not only food and drink but wood and various thatching materials and fibres which form the basis of the local technology. In some of the atoll groups such as the Ellice islands and the Tuamotu archipelago the indigenous pandanus has almost as wide a range of uses. Drought and poor soil combine to render fruit and vegetable growing difficult or impossible. Poverty in agricultural resources is, however, to some extent balanced by the wealth of marine products, including pearls and pearl shell, in the atoll lagoons.

Elevated coral atolls of the type of Makatea, Ocean or Rennell tend to have a more fertile soil which supports a greater variety of food plants and timber trees. On many of them, too, rich deposits of phosphate cover the surface. But in the absence of a central lagoon, marine resources are poorer than on the low atolls.

The high islands, wholly or partially of volcanic origin, are by far the richest in variety of resources. Their igneous and metamorphic rocks have yielded valuable minerals in many areas. They are well watered, contain the most fertile soils in the Pacific, and are thickly covered with vegetation. The forests contain valuable species of timber trees and yield minor products such as gums and resins. Native food crops and most of the tropical plantation crops flourish. Stock rearing and dairying are possible in the higher and more open parts. As the coasts of the high islands frequently possess lagoons behind barrier reefs, they sometimes share abundant marine resources with the atolls. Table II (p. 526), showing exports, also gives a picture of the distribution of the main resources.

Consumption levels in the various groups are closely related to the systems of production and utilization of resources. In some

territories, such as the Cook islands or the Gilbert and Ellice islands, effective ownership and exploitation of resources is largely in native hands. But with their lack of capital and relatively simple methods of production, native peoples do not as a rule develop local resources far beyond the level at which their needs of subsistence can be met. Increases in consumption levels have therefore been achieved mainly by the more intensive exploitation of existing resources and the introduction of new resources by Europeans. Such development has been possible only where adequate foreign capital and labour have been forthcoming.

There is no reliable index of relative consumption levels in Pacific islands territories. The *per capita* figures of imports given on p. 527, apply to total populations and lump together natives, Asiatics and Europeans, whose respective money incomes and standards of living differ very greatly. It is impossible to separate completely the imports which go to supply the wants of the different sections of the population, and even difficult sometimes to separate capital goods from consumption goods. Nor can the proportion of real income derived from subsistence production or from internal trade be easily calculated. But if we compare areas—e.g., the Cook islands, Tonga, the Gilbert and Ellice islands, and Niue—where European population is small, *per capita* import figures give some indication of the relative poverty and wealth of the native communities, in terms of what they can afford to buy from abroad.

In Hawaii, with the help of abundant foreign capital and labour and modern technology, the local resources have been enormously increased in quantity and value so that the standard of living is generally similar to that of many parts of the mainland United States. Nevertheless there is a wide gap between living conditions of the wealthiest and poorest in the territory, and in recent years there has been much unemployment. In such groups as the Cook islands or the Gilbert and Ellice islands, the predominantly native population has a standard of living not greatly above that of pre-European days. The increase depends on the proceeds from the sale of fruit and copra. In comparison with Hawaii, standards of living are low, and the difference between rich and poor is slight.

TYPES OF ECONOMY

The types of economic organization in operation in the Pacific islands show considerable variety. They range from the primitive

subsistence economy of the natives in the interior of New Guinea, and on one or two isolated smaller islands such as Rennell in the Solomons, to the highly developed plantation agriculture of the Hawaiian islands and the mining industry of some areas in Fiji, New Caledonia and New Guinea. Between these extremes are many intermediate varieties of economy.

Native Economic Systems

Native economic systems can only be understood in relation to their setting in the physical environment and in the social systems of the people concerned. Despite the considerable skill and knowledge the natives employ in utilizing what materials are available, the limits of scale in productive organization are soon reached. Cultivation methods and fishing and craft techniques are often of a sufficiently simple order to allow a family to provide for its needs without organization on a wider basis. Production for everyday need is, in fact, very largely in the hands of individuals and families. Nevertheless, the existence of wider social and political units, such as the clan and the tribe, with their social aims and obligations going beyond mere individual subsistence, calls for a more complex economic organization. And indeed some tasks, such as the building of a house, the launching of a canoe, the clearing of a garden plot or the financing of a marriage, demand the co-operation of members of a group larger than an individual family. One of the main functions of these larger units is thus to shoulder the burden of providing more labour and capital for specific undertakings than the average individual or family can command. More spectacular, though, are the essentially 'public' works and expenditure undertaken by these larger units. The erection of public buildings, such as a men's club-house or a canoe-shed, the growing of additional crops to provide food for feasts on special occasions, all call for organization on this wider scale.

Accumulation of capital and consumers' goods is not easy in the damp tropical climate of most of the island groups; food, houses, canoes, and most objects except those of stone and shell decay fairly rapidly. Few of the local cultures put a premium on accumulation by individuals. Prestige is apt to be gained by generosity, so a continual redistribution of wealth takes place. And although individuals often control large resources in the form of land, canoes and valuable cult objects, they normally do so as

trustees on behalf of kinship or local groups; effective use of the capital concerned is shared by the other members as well.

Native systems of exchange show some variety from simple barter necessitated by the local occurrence of various resources to highly elaborate formal exchanges of cult objects. In this latter type of exchange, in Melanesia and Micronesia, various ceremonial objects (often known as currency) (pp. 424–7) may be used.

Relative levels of consumption within any native community seldom vary greatly. There is usually little difference between the quality of food and housing enjoyed by a high chief and his humblest subject. The main possessions distinguishing men of high rank are insignia and cult objects, but even these are frequently regarded as emblems belonging to a wider group and entrusted to the care of its leading representative.

Small-scale Mixed Economic Systems

In most parts of the Pacific the primitive native economic systems have been changedby contacts with the European social and economic system. The need for cash to buy imported European goods, to pay taxes and to contribute to mission funds, has caused native peoples to devote a part of their resources to production for export or to sell their services as labourers on European plantations and mines. This has involved varying degrees of change in organization. In some areas, as in Samoa, little alteration has taken place beyond production within the traditional economic system of a saleable surplus of exportable commodities. Traditional types of consumption goods are still considered indispensable and imported goods serve partly as additions and partly as alternatives to them. The extent to which imported goods are regarded as essentials is shown by the behaviour of natives in different groups during a trade depression. In the period 1930-5 when copra prices fell to a very low level, the less Europeanized peoples like the Solomon islanders did not consider that copra production was worth while and relapsed into their ancient self-sufficient economy. More sophisticated peoples like the Society islanders tended to increase their copra production to offset the reduction in income caused by falling prices.

Production by natives for export tends to be rather spasmodic. Coconuts will be collected and copra made to raise money *ad hoc*—

for the building of a church, the purchase of a boat or to meet the demands of the tax-collector.

Several governments have stimulated the export side of these mixed economies by grants of land for copra plantations, by giving technical advice on agricultural problems and by organizing the collection and marketing of native produce. In terms of organization, some government-sponsored schemes have stressed the collective side of the traditional economic system in attempting to found small producers' co-operative societies, as in the Gilbert and Ellice islands. Others have attempted to encourage individual initiative. In Fiji, men who so wish may free themselves from their communal responsibilities and set up as entirely independent farmers.

The general aims of production remain basically similar to those of pre-European days; only the relatively few natives who have lost their lands and drifted towards the towns and ports live solely by producing fruit and vegetables for the market or by wage labour. Among non-native groups, however, there is considerable small-scale production for sale to local Europeans or for export. On the sugar plantations of Hawaii and Fiji, former contract labourers have become small tenant-farmers who sell the cane they produce to the sugar companies which still own the land and closely supervise production methods. Conditions of tenure frequently preclude the growing of crops for home consumption, so the cultivators practise a full money economy in which they live largely on advance payments on their crops.

Large-scale Export Economy

Production for export by large mining and plantation companies is a prominent feature in some island groups. In most cases it has developed from smaller concerns managed and owned by individuals. Such one-man enterprises are now the exception; their limited capital has been insufficient to carry them through periods of trade depression. Little by little they have been abandoned or bought up by larger and more powerful concerns. These are typical of large capitalist enterprises in the tropics in that the capital concerned is largely provided by European shareholders resident outside the tropics, and the bulk of the labour employed is drawn from non-European groups. Only the administrative and technical posts are

The larger plantation owners frequently combine agriculture with general trading and shipowning. Typical examples in the Western Pacific are Lever's Pacific Plantations, the Burns, Philp group of companies and W. R. Carpenter and Company. The merging of smaller concerns has in some areas resulted in a single firm being left in a quasi-monopolistic position.

As a rule the large companies have been established without any direct governmental assistance, though, especially over the last twenty years, governments have given much assistance in technical research and in protecting markets by tariffs and quota systems. In the Japanese mandated islands, many of the large-scale enterprises were originally controlled by the government, but are now run by private companies in which the government holds a majority of the shares.

LAND

Problems of land tenure are of great economic importance in the Pacific islands, since they so often determine the nature of land utilization. Other factors, both of environment and of technique, affect utilization. Traditional native agriculture, in common with that of other damp tropical regions, is largely of shifting type. Thus, the area actually used by natives at any given time meets only a fraction of their needs. But some crops which are slow in maturing or which demand special conditions are of a permanent nature. Yams, sweet potatoes, sugar cane, bananas, and dry-land taro, in the absence of fertilizers, must be grown by the shifting method. But coconut palms and the larger fruit trees are permanent crops and wet-land taro is confined to natural or artificial swamps.

In the low islands, the native communities have been left in almost undisturbed occupation and retain their ancient forms of land utilization, since their lands have not proved attractive to European settlers. On such islands population is generally maintained at such a level that all available land is used for house-sites, gardens and coconut groves. The high islands, by contrast, have in many instances attracted European settlers. Native population, too, though generally dense at the time of discovery by Europeans, had probably not reached the same high ratio to available land. Depopulation (p. 347) has been severe on many of these islands. European settlers have therefore found abundant land available for plantations and mining. Nevertheless, the proportion so used is seldom high.

Statistics for mining relate principally to areas over which prospecting licences have been issued and not to those actually utilized. Some governments, however, record the area of land used for European plantations. It represented in the Hawaiian islands 8.5% of the total in 1930; in Western Samoa, 2% in 1928; in the New Hebrides, 1.5% in 1938; in the Solomons, 0.6% in 1938; in the Territory of New Guinea, 0.9% in 1940; and in Papua, 1% in 1939. In Fiji the total area of land owned by non-natives is about 9%. The bulk of the remaining land in most territories constitutes native cultivation areas and forest reserves.

European holdings may thus not appear extensive, but they generally embrace the most fertile lands and the bulk of lands near urban centres. The latter fact is unfortunate for the natives, since it is there that the native populations are increasing most rapidly; the result is an increase in the number of landless individuals in these localities. Some land is held by governments for buildings, roads, research stations, and for defence and other purposes; but this forms a very small proportion of the total, except where, in addition, the government also assumes ownership of unoccupied land.

History of Land Dealings

Before the arrival of Europeans, the native system of land-holding in the Pacific rarely gave absolute rights of ownership and disposal to individuals. Land was normally owned by kinship groups—clans, sub-clans, etc.—with families and individuals having rights of residence, cultivation, and other usufruct there. Such rights were transmissible by virtue of descent as a member of the group. Land was rarely transferred by one group to another, except as a result of war, though in some communities lands were handed over by one group to another as compensation for injuries or as a gift at marriage of important people.

Europeans in their early dealings with Pacific islanders did not realize the implications of ultimate control and ownership of land by a group, and numerous misunderstandings arose. Tracts of land were often bought from native occupiers who were thought to be the owners. Natives, on their side, parted with land on the assumption that it was being rented or leased rather than sold outright; and they all too readily exchanged land for firearms, liquor and worthless trinkets. The earliest attempt to establish a system of

1846 King Kamehameha III appointed a commission to divide the lands of the kingdom between himself and the chiefs. The work of the commissioners and the public discussion which it aroused led to a broadening of the basis of reform. The lands were eventually divided into four categories—those of the king, of the government, of the chiefs, and of the common people—and a general system of freehold tenure was introduced. This certainty of tenure was a powerful encouragement to European settlers, with the result that the lands passed out of native ownership even more rapidly than before. In Tonga, on the other hand, the early assumption of control of all land by the Crown, with grants to nobles and commoners without giving them freehold or rights of alienation, secured land against appropriation by foreigners (vol. III, p. 72).

When Western administrations, or native governments with European advisers, were established in the various territories, one of their first tasks was putting an end to this uncontrolled dealing in land and settling the numerous disputes that arose from it. Lands and survey departments were set up and land courts and commissions established. Surveying made slow progress, owing mainly to shortage of staff and funds and in some areas to the difficulties of the terrain. Land courts have progressed at a similar rate, being hampered partly by the conflicting claims of Europeans—in Samoa such claims covered more than double the area of the territory—and partly by the intricacies of the native titles to land and the ambiguities of native systems of delimiting properties.

Land Policies

The general aims of government land policies have undergone considerable changes. Originally their chief concern was to establish European titles on a sound basis and to settle disputes on land questions between Europeans. But with a growing concern for native welfare, the emphasis has shifted to native land-holding, with the aim of retaining adequate lands for present and future native needs. In Hawaii and New Caledonia, where most of the land has passed from native hands, some restitution has recently been made. In the former, native Hawaiians have been settled in small numbers on 'homesteads' (small-holdings intended for mixed farming). In the latter, reserves have been established for the native population (a policy which also favoured European interests by freeing large tracts for European settlement). Elsewhere, government land

policies have tended to check further European expansion. They have forbidden sales of land by natives to non-natives, or at least allowed them only under close official supervision. Policy as regards lands not actually used or occupied by Europeans has varied in the different territories. In some, as in Fiji, no further sale of land to Europeans is permitted and all non-alienated land is held to belong to the natives. Non-natives may only lease such land. In other territories such as the Solomons or New Guinea, where native populations are relatively sparse and land surveys are in their infancy, natives have generally been left in undisturbed possession of the land they occupy and all other lands have been vested in the government as trustee for the native population. Except for the areas obtained freehold in the past, Europeans may only lease land from the government. And wherever leases have been granted, precautions have been taken to ensure that immediate native interests are not threatened ; village sites adjoining plantations are constituted native reservations and may not be encroached upon. Perhaps the most striking example of this emphasis on trusteeship is provided by the phosphate islands of Ocean and Nauru, where the natives lease their land to the British Phosphate Commissioners and in addition receive a royalty based on the tonnage of phosphate extracted. In the Japanese mandated islands all land not privately owned by natives and others at the time of the occupation of the islands was held to belong to the state. A considerable proportion of this state land has, however, been leased or even sold to individuals (mostly Japanese immigrants).

Tonga is the only territory which has preserved largely intact its ancient feudal system of tenure ; all land is ultimately vested in the Crown and various noble families but is available for use and occupation by commoners. Each is granted an allotment for cultivation and another for residence.

Present-day Systems of Land Tenure

Native land tenure today still follows traditional principles in most of the island territories. The chief departures from tradition are those already noted in New Caledonia and Hawaii. Elsewhere the old systems have been more or less modified by the impact of Western legal systems and the individualistic economy. Governments have tacitly accepted the ancient systems or taken the further them the sanction of civil law. For the decay of native

cultures, in which titles to land are based on genealogies and other forms of oral tradition, has led to numerous disputes. Forceful personalities, conveniently ignoring or openly disputing ancient titles, have tried to gain lands at the expense of their fellows. Governments in the interests of equity are, therefore, often obliged to maintain the traditional collective systems of tenure. As surveys progress, and as native land courts and other organizations gradually determine titles, disputed claims become fewer. A difficulty still exists, however, as to the extent to which it is permissible and practicable to maintain the traditional forms of group ownership or to introduce Western forms of individual ownership.

The Asiatics who have settled in European-controlled territories have as a rule but a small stake in the land. If they are allowed to hold land at all it is generally as tenants. The Indian peasant farmers in Fiji thus either lease their land from Fijians or from the Colonial Sugar Refining Company. In the Japanese mandated islands, the non-native landholders are, of course, predominantly Japanese. Some possess as freeholds lands which had been alienated under the German regime; others have bought or leased state land from the present government.

European tenure is similarly varied in character. Land acquired in the early days before government control is usually held freehold, but land obtained more recently is generally leased either directly from the native owners or from the government which holds the land in trust for the natives. In some territories, including the British Solomon Islands Protectorate, where there is a risk of conflict of interests between Europeans and natives, the government frequently grants land to Europeans under a temporary occupation licence.

LABOUR

The demand for labour by European employers today is as keen as it was in the later nineteenth century (Chapter X, pp. 300–7). Some of the native peoples show little enthusiasm for work in mines or plantations, since thay can still supply their essential needs of food and shelter and provide themselves with a limited range of conventional luxuries—such as tobacco—from local resources, including the production of copra, bananas, etc. On the other hand, in many islands there is considerable desire among young men to enlist as labourers in order to obtain cash for imported goods and even to gain prestige from having worked for white men.

Types of Labour Employed

Some form of government supervision over the employment of labour and the conditions under which it works exists in most Pacific territories. The systems under which it is employed and the type of labour employed vary from territory to territory. In those, like Fiji or Hawaii, which have long been settled by Europeans, conditions of employment are as free as in most European countries, though wages are by comparison low; in general, the heavier and more unskilled types of manual labour are performed by natives or Asiatics. In the less developed territories, indentured labour is the rule on plantations and in mines, and in some cases for public works. Indentured labour is employed in Papua, the Territory of New Guinea, the Solomon islands and the Gilbert and Ellice islands. In the Japanese mandated islands native indentured labour is used in phosphate mining, but the bulk of the labour force consists of indentured and free Japanese working in the sugar plantations and mills. The French have imported Javanese and Indo-Chinese labour on a considerable scale into New Caledonia and the New Hebrides and on a minor scale into French Oceania. Chinese contract labour is employed in phosphate mining on Nauru, and free Chinese labour on the plantations in Western Samoa. The numbers of indentured labourers employed in these territories about 1938 were as follows:

Territory	Class	Number	Year
Territory of New Guinea ..	Native	41,849	1938
Papua	Native	9,648	1937–8
British Solomon Is. Prot. ..	Native	5,303	1937–8
Gilbert and Ellice Is. Colony	Native	650	1937
,, ,, ,, ,, ..	Chinese	780	1937
Nauru	Chinese	1,486	1939
New Hebrides	Tonkinese	2,023	1938
,, ,, ...	Native	772	1938
New Caledonia	Javanese	7,735	1939
,, ,, ...	Tonkinese	2,261	1939
Japanese Mandated Is. ..	Japanese	11,000 (approx.)	1937
,, ,, ,, ..	Native	304	1937

Nearly all indentured labourers of all races are men. Most administrations prohibit the recruiting of women or allow it only under special circumstances. Thus, in some British territories, native women are allowed to do domestic work under contract to a

European woman. As a rule, also, labourers may not take their wives with them when they go to work on plantations ; but, in the case of native labour, governments sometimes leave this to the discretion of the employer. Few Asiatics bring their wives with them owing to transport costs.

Official Labour Policies

The present attitudes and policies of Pacific islands governments to labour questions have been shaped by a variety of factors. One of the most important of these is the memory of the labour traffic of the nineteenth century. The evils attendant on this trade were so serious and so well publicized that the governments concerned have since framed their labour policies with considerable care. Wherever it has been possible to obtain sufficient labour without the compulsion inseparable from the indenture system, it has been policy, in British territories at least, to encourage the use of free labour. But where the alternatives are the use of local or Asiatic labour under indenture, British governments have considered that native welfare was better served by employing local labour. The poll tax imposed on natives under some administrations, as one of its functions, provides an incentive to work for wages under European employment. The general view has been that the introduction of foreign labour is liable to spread diseases, and that social contacts and sexual intercourse between natives and Asiatics are undesirable.

The establishment since 1919 of League of Nations mandates over the former German colonies has had an appreciable influence on the labour situation in these territories. Although the Permanent Mandates Commission of the League of Nations cannot enforce its decisions on labour problems and its powers are largely advisory, it has had considerable influence on the formulation of labour policies. It has all along been opposed to any system of forced labour and has merely tolerated indentured labour as more or less inevitable at this stage in the development of the countries concerned. Its main effort has therefore been directed to ensuring reasonable conditions for the indentured labourers.

In territories administered by Australia and New Zealand, various local factors complicate labour issues. Australians, with their 'White Australia' policy of over forty years' standing, are extremely averse to any influx of Asiatics into the islands fringing their northern shores. Views on native welfare are perhaps not uninfluenced by this policy. It is held that the use of large numbers

of natives in mines and plantations in Papua and New Guinea is a suitable way of introducing them to the European money economy; and, as an incentive to this, all labourers in New Guinea are exempted from the poll tax. Nauru provides an exception to this general Australian policy. The native population was too small to provide sufficient labourers for phosphate working, and Melanesians imported from New Guinea fell victims in large numbers to tuberculosis. The government therefore agreed to the importation of Chinese labour.

The only territory controlled by New Zealand where plantation agricultural is well enough developed to raise labour problems is Western Samoa. Here, the German administration had left as a legacy a labour force of over 2,000 indentured Chinese; but opinion in New Zealand, particularly within the Labour Party, objected on principle to indenture, considering it a mild form of 'slavery'. As a result of agitation, the New Zealand government in 1923 ended the system of indenture between employer and labourer and substituted a form of indenture between labourer and administration, leaving the labourer free to choose his employer. After the Labour Party came to power in New Zealand in 1935, this system was abolished and the work of repatriating the Chinese was begun. Their place was to be taken by Samoans and natives of Niue under free contract.

In her mandated islands, Japan has not followed very closely either the letter or the spirit of the mandate. In these islands labour problems are concerned mainly with the phosphate mines on Angaur and Pelelin and with sugar cultivation on Saipan, Tinian and Rota. In the mines indentured natives from the neighbouring islands constitute the labour force; in the sugar industry labour is provided by Japanese immigrants from the Ryukyu islands. In 1937 about half the total of 21,000 consisted of indentured labourers working in the sugar plantations and refineries; the remainder consisted of Japanese families growing sugar as tenant farmers on the sugar company's land. Local labour legislation is largely in the hands of the Governor of the South Seas Bureau. Problems of labour legislation and conditions are entirely subordinated to the rapid economic development of the territory. Indentured labourers, both native and Japanese, have few legal safeguards. The Angaur workers, for instance, are engaged under verbal contracts, and receive neither free medical care nor, in cases of disablement, any compensation. For the Japanese labourers there is no proper

repatriation policy; labourers sign successive contracts and remain in the islands indefinitely.

Conditions of Recruitment and Indenture

There is a general similarity in the system of recruitment and indenture for native labourers, at least in British-administered territories. Employers must contribute to the cost of recruitment and repatriation. Recruiting is generally carried on by Europeans who must satisfy the government that they will abide by the recruiting regulations. They must hold special licences for recruiting and must not combine trading with recruiting activities. Recruits must not be bought from their tribes. All recruits obtained are medically examined by government medical staff and their contracts signed in the presence of an administrative officer. Contracts usually last for a period of two or three years. Though in the mandated territories the Mandates Commission is averse to the renewal of contracts, some local administrations have yielded to pressure from plantation and mining interests and in practice countenance renewal of contracts for further periods. Contracts are generally maintained with the support of penal sanctions.

Wage scales are fixed by governments. Wages, which must be paid in cash with the addition of free food, clothing and housing, are generally low and fluctuate according to the state of world trade. Thus, over the last fifteen years, wages paid to native labourers on coconut plantations have varied between 10s. and £1 a month. Native labour in the phosphate mines on Angaur received about 50 sen per day (i.e., about 15s. per month). Minimum standards of diet and housing are laid down by most governments and are generally subject to official supervision. Typically, natives are housed in corrugated iron buildings of the coolie-line type (Plate 152) or in thatched houses. Diet varies considerably. In the past the staple foods have largely been imported rice and canned meat, but recently governments have encouraged employers either to use part of their land for growing vegetables for their labourers or to allow the latter vegetable plots in the neighbourhood of their quarters. In addition to food and shelter, most administrations insist on the labourers being provided with clothes, blankets, soap and tobacco.

Asiatic indentured labour is employed under generally similar conditions to native labour except that wages are generally on a higher scale. Thus, on Nauru, ordinary Chinese labourers are

paid from 32s. to 36s. per month and mechanics from £5 to £6 10s. per month. In Saipan and Tinian, the Ryukyu islanders employed in the sugar industry receive wages ranging from 60 sen to 3 yen per day (i.e., from about £1 to £5 14s. per month).

CAPITAL

One factor limiting economic development in the islands has been the amount of available capital. In the trading phase of development in the nineteenth century, the amount of capital involved was relatively small and each trader relied on his own resources. When the general change-over from trading to agriculture took place, small plantations were established both by fresh immigrants and by successful local traders who invested their savings in land. These early planters pioneered the growing of tropical crops for export, for outside investors were unwilling to risk capital in any plantation venture until a steady and remunerative market for its products could be assured. With their relatively low degree of capitalization these early plantations were at the mercy of market fluctuations, and very little expansion took place until some of those which survived the early setbacks attracted outside capital or were absorbed in new companies promoted outside the islands. In the latter way, many coconut plantations in British territories were united about 1898 under the control of the Pacific Islands Company, Ltd., a concern whose interests were later taken over by Lever's Pacific Plantations, Pty., Ltd.

Mining, in contrast to plantation agriculture, has from the beginning attracted the external investor. As early as 1858, the American Guano Company was formed to work the phosphate deposits on some of the central equatorial islands. In New Caledonia nickel working on a large scale was begun in 1875 by the French Société Le Nickel. And when, in the last twenty years, gold in paying quantities was discovered in New Guinea and Fiji, capital flowed in rapidly, especially from Australia.

Political and military, as well as economic considerations have influenced the investment of Japanese capital in the Pacific islands. Both state and private capital have been poured into the Japanese mandated islands to develop them as sources of tropical produce. And considerable Japanese capital has also flowed into other island territories for mining and other enterprises with a view to developing resources of strategic value at points within easy reach of Japan.

In few of the island groups has any attempt been made to reckon the total value of capital invested. In 1929 the planters of Hawaii estimated that their plantations were worth between \$150,000,000 and \$175,000,000; most of this total comprised the re-invested surplus accumulated by the plantation industry itself. Capital has increased so rapidly in Hawaii that for the last forty years at least the territory has been independent of foreign investment. Much local capital has found an outlet in new enterprises. For instance, when expansion of the sugar industry reached its economic limit, the planters transferred their surplus capital to other types of farming and financed pineapple and coffee plantations and cattle ranches. The Matson shipping line is also largely financed by Hawaiian capital.

In Fiji, the investment in the Colonial Sugar Refining Company's properties has been estimated to be about £3,000,000. In the Territory of New Guinea the 31 gold mining companies operating in 1937 possessed a total capital of about £7,500,000 sterling. In the same territory the capital value of coconut plantations was estimated in 1936 at about £4,000,000 sterling.

PRODUCTION

Production in the Pacific islands can be fairly clearly divided between production of foodstuffs and other goods by natives and Asiatics for local consumption, and production of goods for export, mainly by large European firms, but also by natives and Asiatics. The only statistics available as a rule are concerned with exported goods. They therefore do not give an accurate picture of the total production of those goods which are partly consumed locally. The amounts of goods produced solely for the local markets are rarely, if ever, recorded. Comparative figures (p. 527) of exports per head of population in 1938 are of some value, if it is remembered that, in addition, in most island groups the native population still grows most of its own food and produces many of its household requirements from local materials.

Throughout the Pacific islands as a whole, the major emphasis in economic life is on primary production. Very little processing of local products is carried on except in Hawaii and to a lesser extent in Fiji, New Caledonia and the Society islands.

MINERAL PRODUCTION

Mineral resources with the exception of phosphate are confined to the 'high' islands with rocks of volcanic origin. And as only a fraction of the mineral deposits as yet known and suspected has been exploited, it appears that there is great scope for the future development of mining. Many territories too have been unable so far to carry through surveys which would help prospecting. The sources now being exploited have been discovered by private prospectors, often labouring under great physical hardships. Capital for mining has been readily forthcoming.

Gold (Plates 154, 157)

Gold production in the Pacific has always been closely associated with Australian financial and mining interests. And since the main areas are in British territory, the general policy of employing local native labour has been followed. By 1938 New Guinea, Fiji and Papua were in the aggregate producing about 500,000 oz., valued at over £2,800,000. This represented about 0.8% of the world gold output in that year.

Gold was first discovered in paying quantities in Papua about 1889. Production since then has continued both in the Louisiade archipelago and on the mainland. In the Mandated Territory of New Guinea a rich field was discovered in the Morobe area on the mainland in 1926. Several large companies were formed with capital drawn from Canada, Britain and South Africa, as well as Australia. The necessary dredging and other machinery was flown piecemeal to the area and local hydro-electric power stations were set up. The amount of gold exported from this field and one or two other minor fields has risen from 10,000 oz. in 1926 to over 490,000 oz. in 1939–40. The total quantity exported over the period 1921–40 exceeded 3,000,000 oz.

In 1932, commercially-paying quantities of gold were discovered in Fiji, both in Viti Levu and Vanua Levu, and companies were formed with Australian capital to develop these new fields. Exports have risen from 311 oz. in 1932 to over 108,000 oz. in 1939. The numerous traces of gold in New Caledonia and the Solomons have not led to any large field being developed ; but it is thought likely that there are sufficient quantities in the interior of Guadalcanal to warrant large-scale exploitation as soon as communications with the coast are well enough developed.

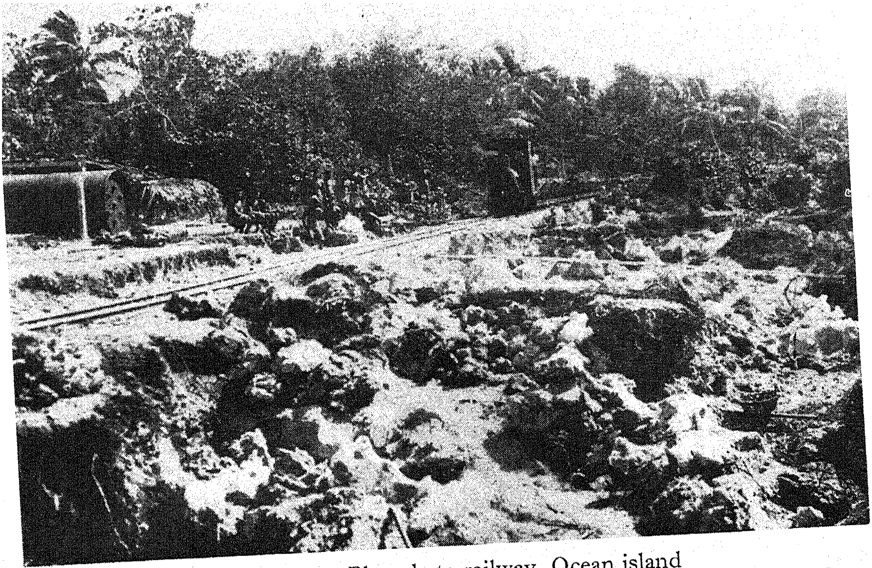

Plate 155. Phosphate railway, Ocean island
The phosphate is carried by light railway from near the quarries to the loading pier.

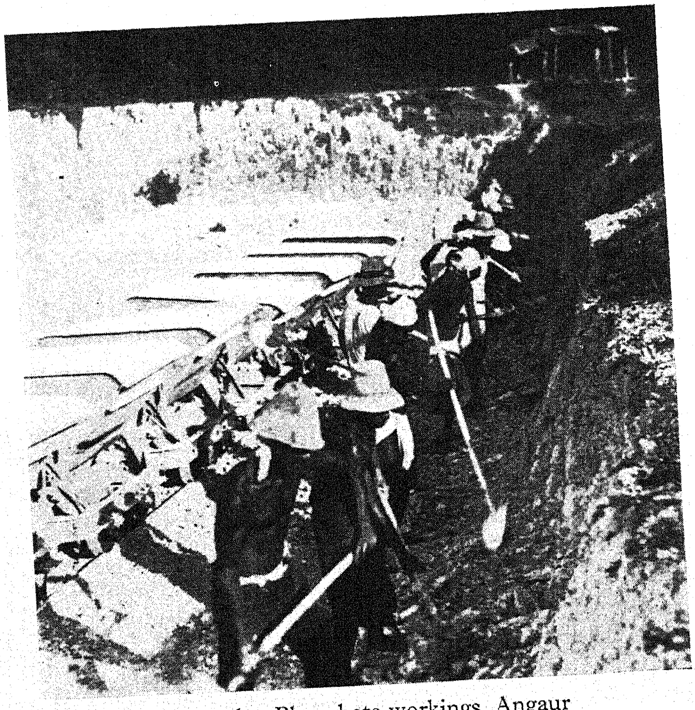

Plate 156. Phosphate workings, Angaur

Plate 157. Tavua goldmines, Viti Levu, Fiji

These are the Emperor and Loloma mines at Vatukoula. On the extreme right is the power station ; in the background is the Kauvandra range of mountains.

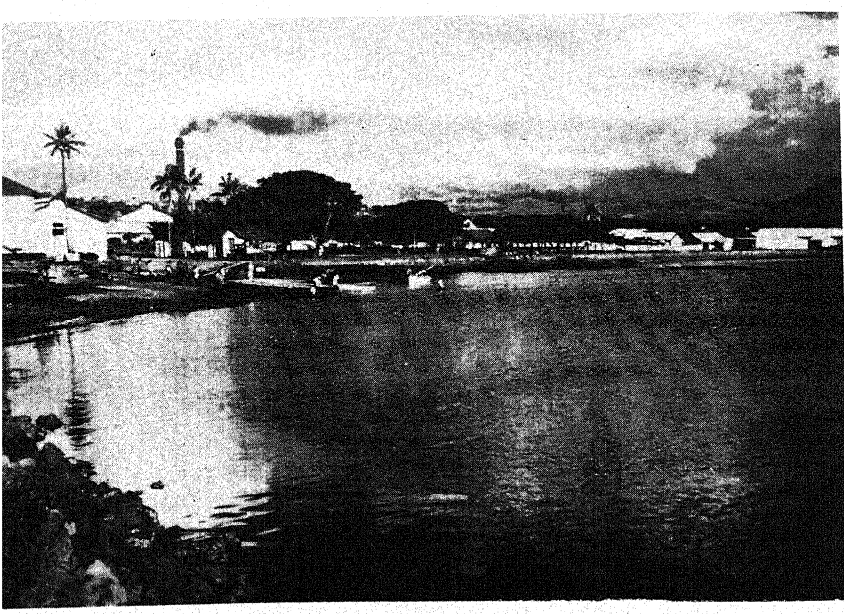

Plate 158. The sugar mill at Lautoka, Fiji

Chromium and Nickel

Since the late nineteenth century, chromium (in the form of the oxide chromite) has been mined in large quantities in New Caledonia. Production in 1938 comprised about 5% of the world output. Both large and small companies with French and some British capital are working the deposits. Nickel ore also occurs abundantly in New Caledonia and has been exploited for a similar period. The island is the second largest producer in the world and over the period 1930–8 contributed nearly 12% of the world production. Most of the output is now processed locally to form nickel *matte*, a partially refined ore, for export. In 1935, Japanese interests secured nickel mining concessions to be worked by local labour.

Phosphate (Plates 153, 155, 156)

Before 1900, minor deposits of phosphates were worked by British and American interests on several of the central equatorial islands. In that year came the discoveries of large deposits on Ocean and Nauru, followed shortly by similar discoveries on Makatea in the Tuamotu archipelago and on Angaur in the Palau group. The Ocean and Nauru deposits are now worked by the British Phosphate Commissioners, the Makatea deposits by an Anglo-French company, and the Angaur deposits by the Japanese government-controlled South Seas Colonization Company. Production at all four islands has continued at an ever-increasing rate. Between them, they supplied in 1937 a total of over 1,380,000 tons. The minor deposits on various other islands off the coast of New Guinea and in Tonga, Fiji and elsewhere are not sufficiently paying in quantity or quality to warrant their exploitation.

Other Minerals

Few other minerals are now worked to any extent. Cobalt *matte* and ore were exported in some quantity from New Caledonia up to 1910 but the export was killed by the rise of Canadian cobalt production. The production of low-grade iron ore has recently been developed by the Japanese on their concessions in the same island. Some coal is mined there for local use. Copper was mined in some quantity near Port Moresby in Papua until 1927, when falling prices put an end to operations. Small quantities of osmiridium have been extracted from the goldfields of both Papua and the Territory of New Guinea.

Agriculture is the foundation of nearly all the island economic systems, since it almost everywhere provides the basic food supply of the population and the major export commodities. The most notable exceptions are New Caledonia and New Guinea, where agricultural exports are eclipsed by those of minerals.

The traditional native methods of agricultural production have already been described (p. 416); the following account is confined to the major export crops. In their case, production has been continually hampered by problems of fluctuating market demand, of labour supply and of transportation, and to a lesser extent by natural disasters in the form of hurricanes, plant diseases and insect pests.

Copra (Plates 159–60)

The production of copra, the dried flesh of the coconut, is widespread throughout the tropical Pacific. In some territories such as the Gilbert and Ellice islands (excluding Ocean island), the Phoenix group, the Marshall islands and the Solomon islands, copra is the only large export. Total production by Pacific islands territories in recent years has averaged about one-eighth of world production. Other coconut products including husked nuts, desiccated coconut and copra refuse are produced in small quantities in some territories, particularly those controlled by Australia, which offers them a protected market.

In the Solomons, the Territory of New Guinea, Papua and the New Hebrides, copra production is predominantly a European plantation industry in which native or imported Asiatic labour is employed. In fact, in these areas coconuts are held to be the most suitable plantation crop because the comparative simplicity of cultivation techniques suits the local labour force, there is no large outlay on machinery, and transport difficulties tend towards coastal development where soils are the most suitable. Elsewhere the bulk of copra production is in native hands.

As labour costs have been high and prices over the last twenty years have been generally low, considerable economies in production methods have been forced on European planters. Large concerns such as Lever's Pacific Plantations in the Solomons and the German Reparations Estates in Western Samoa have weathered the depression more successfully than the small planters by reason of their more

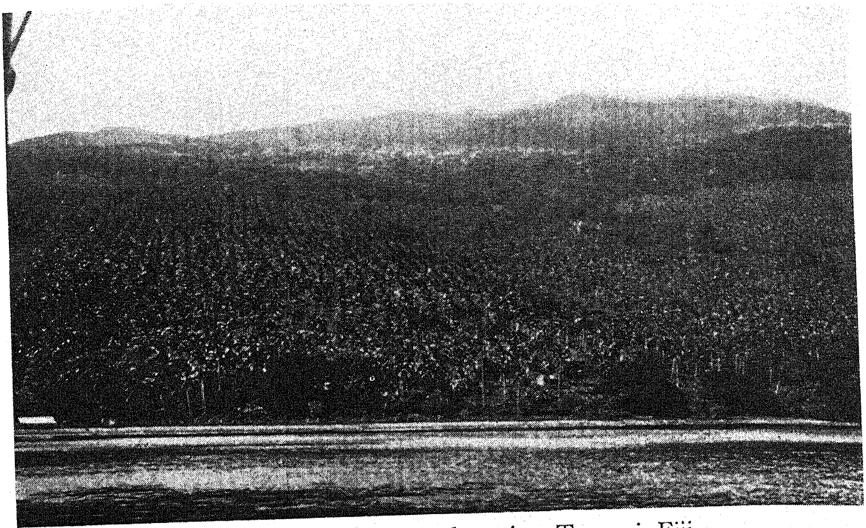

Plate 159. A coconut plantation, Taveuni, Fiji

Plate 160. A coconut plantation in Papua
The palms here are all quite young. In the foreground a native labourer is cutting copra.

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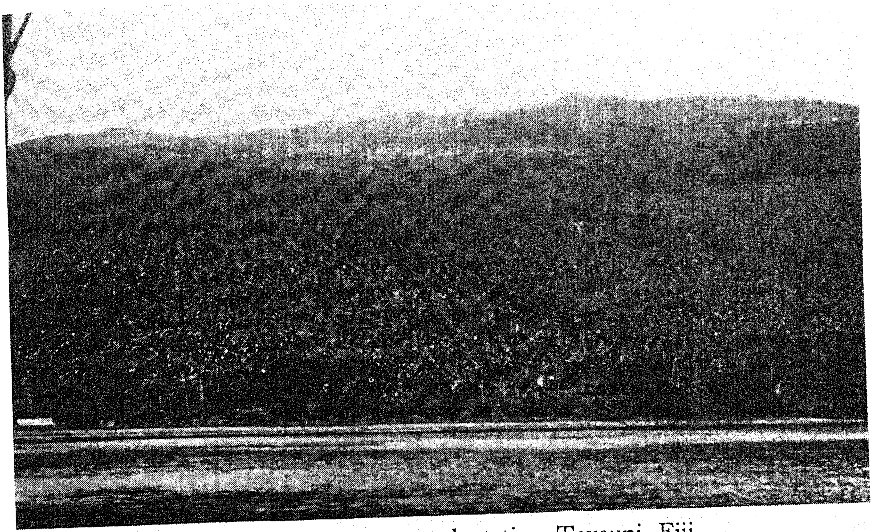

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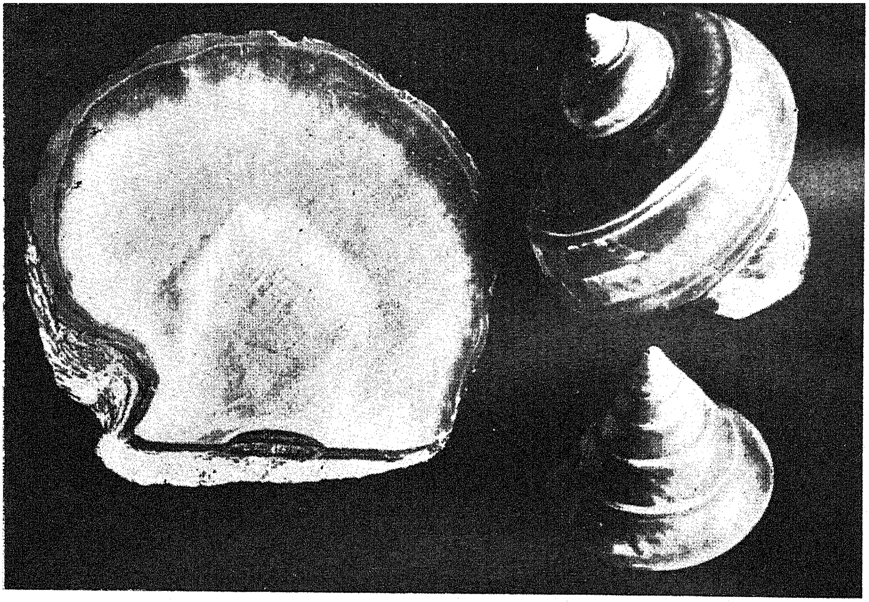

Plate 161. Three sources of mother-of-pearl

On the left is the pearl oyster; top right is a green snail; and bottom right is a trochus shell. The last two have had their rough outer layer removed to show the pearl shell beneath.

Copra Exports, 1938

Territory	Tonnage	Value (£ sterling)	Native production as percentage of total production
Fiji	33,480	240,720	60
British Solomon Is. Prot. ..	22,940	259,370	?
Gilbert and Ellice Is. Colony	4,850	43,850	100
Tonga	12,430	72,030	95
Territory of New Guinea ..	73,720	675,490	?
Papua	11,250	73,040	?
Western Samoa	11,240	83,090	77
Cook Is. and Niue	1,300	8,320	100
New Hebrides	11,450	74,920	16
New Caledonia	2,950	25,180	63
French Oceania	20,680	149,560	75
Japanese Mandated Is. ..	13,100	117,450	?
Guam	1,660	24,540	100
American Samoa	800	11,310	100

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 323 (London, 1942).

industrialized methods of production. Estates employ hot-air drying-kilns to produce their copra. Official propaganda in several territories has tried to persuade native producers to adopt small types of hot-air dryers instead of the crude smoke dryers which they normally employ.

Cane Sugar (Plate 158)

Cane sugar is grown as a plantation crop in Hawaii, Fiji and the Marianas. In Hawaii there are 48 large plantations and over 300 small-holdings. The plantations co-operate voluntarily in research through the Hawaiian Sugar Planters' Association. Hawaiian sugar cultivation is now highly industrialized and recognized as the most efficient in the world. Production is now about 1,000,000 tons per annum and goes wholly to the United States. Since 1943 it has been limited by the federal government to 14% of the mainland requirements. The final processing of the sugar is carried out on the mainland.

In Fiji the Colonial Sugar Refining Company, an Australian organization, is in a monopoly position. It has five sugar mills. It owns nearly all the 90,000 acres of cane land, but leases most of this in small lots to Indian and Fijian tenant farmers. The tenants operate under close supervision by the company to which they sell

their crop. Output has been limited by Empire sugar agreements in recent years.

The sugar industry centred on Saipan in the Marianas has been developed by the Japanese since they occupied the islands during the war of 1914-18. The two small companies which started the industry amalgamated to form the South Seas Development Company. It possesses a monopoly and the government maintains a controlling interest in it.

It is unlikely that further great expansion of the industry in the Pacific will take place unless new uses are found for sugar, as world markets tended to be glutted before the war.

Fruit

Fruit production for export in the Pacific is of two types: large commercial planting and canning of pineapples, centred mainly on Hawaii but also developed since 1936 in Fiji; and small-scale production of bananas and to a lesser extent of citrus fruit by native small-holders, especially in the New Zealand dependencies and in Fiji. There is also fruit production on a minor scale by European small-holders in such marginal islands as Norfolk and Lord Howe.

The Hawaiian pineapple industry is run by a few large companies which, like the sugar companies, maintain a joint research body, the Pineapple Producers' Co-operative Association. Pineapple exports, which over the period 1937-9 averaged about £10,000,000 in value, go almost exclusively to the protected market of the American mainland. Fijian pineapple growing and canning has been developed since 1936 by the Colonial Sugar Refining Company and was expanding rapidly when the present war interrupted production.

Banana growing was formerly a European plantation industry in Fiji and Samoa, and considerable exports were sent to Australia. But the ravages of diseases on the plantations and the imposition about 1920 of a high Australian tariff to protect the Queensland growers drove most of the Europeans from the business. This left the limited market of New Zealand as the only outlet for the island growers. The New Zealand government since the 1931 depression has established quotas and fixed prices for bananas from Western Samoa, the Cook islands, Niue, Fiji and Tonga. In Western Samoa banana growing still survives as a plantation industry, but in all these territories it is government policy to encourage the islanders to grow bananas as an alternative export crop to copra.

Vegetables

The growing of vegetables (as of fruit) has been encouraged in several territories in order to diversify the native production for export. Fiji and the New Zealand dependencies supply small quantities for the New Zealand market but most of the production is consumed locally, particularly in the larger settlements. The present war has added the further incentive of local self-sufficiency. Europeans in the island territories had been accustomed to import considerable quantities of temperate-zone vegetables, but shipping difficulties have stimulated local production to replace these imports.

Coffee and Cocoa

Coffee and cocoa have both been tried as plantation crops in many of the island groups, but limited demand and low prices, coupled with competition from other areas, have severely hampered the industries. Coffee is still produced on a plantation scale by Europeans in New Caledonia, the New Hebrides, New Guinea and French Oceania. In Hawaii it is grown by Japanese and other small-holders; the product is mostly consumed within the territory. Figures of production in these territories in 1938 were as follows:

Coffee Production

Territory	Acreage	Tonnage	Value (£ sterling)
Hawaii	4,500	2,834	147,400
New Caledonia	?	1,767	71,000
New Hebrides	7,000	437	13,800
New Guinea	1,245	41	800
Papua	368	83	5,300
French Oceania	?	75	2,300

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 326 (London, 1942).

Cocoa production has suffered more severely from modern marketing difficulties. It is grown on a commercial scale in the New Hebrides, Western Samoa, and the Territory of New Guinea. That grown in Samoa is in special demand owing to its fine flavour. It is used for blending with other varieties. Production figures for 1938 are shown on the following page.

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Territory	Acreage	Tonnage	Value (£ sterling)
Hawaii	4,500	2,834	147,400
New Caledonia	?	1,767	71,000
New Hebrides	7,000	437	13,800
New Guinea	1,245	41	800
Papua	368	83	5,300
French Oceania	?	75	2,300

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 326 (London, 1942).

Cocoa production has suffered more severely from modern marketing difficulties. It is grown on a commercial scale in the New Hebrides, Western Samoa, and the Territory of New Guinea. That grown in Samoa is in special demand owing to its fine flavour. It is used for blending with other varieties. Production figures for 1938 are shown on the following page.

Cocoa Production

Territory	Acreage	Tonnage	Value (£ sterling)
New Hebrides	9,000	1,893	28,300
Western Samoa	5,000	1,647	47,760
New Guinea	2,200	179	3,610

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 327 (London, 1942).

Rubber

Climatic and soil conditions in many of the Pacific territories are very suitable for rubber growing. Para rubber cultivation on a plantation scale was begun in Papua, Western Samoa, Hawaii and Fiji in the first decade of the present century, but low prices during the last twenty years and competition from Malaya and the Netherlands East Indies have put an end to production except in Papua, for which Australia provides a protected market. Production in all these territories has been stimulated again by the present war.

Miscellaneous Agricultural Production

Rice is grown for local consumption wherever immigrant Asiatic populations are established. Now, the largest amount is grown in Fiji, where the Indian small farmers produced about 10,000 tons in 1923. In Hawaii, owing to competition from Californian rice, the area of rice fields cultivated by Chinese fell from over 9,000 acres in 1900 to under 1,300 in 1936. Vanilla cultivation is confined mainly to French Oceania, where there was a boom after 1920. The 1938 output was 124 tons, valued at just over £7,000. Small quantities of kapok and sisal hemp are exported from the Territory of New Guinea.

Livestock and Dairying

Cattle, sheep, pigs and horses are kept in varying numbers in most of the island groups, but it is only in a few of them that meat production or dairying is practised to any great extent. The native communities nearly everywhere keep small numbers of pigs, and Europeans keep cattle on coconut plantations, primarily to graze down the undergrowth but also to provide meat. In Hawaii and

New Caledonia, however, where there are large areas of suitable grazing land, specialized ranching is of considerable importance, with over 100,000 head in each territory. In Hawaii the beef is consumed locally; in New Caledonia it is partly consumed locally and partly canned for export.

Dairying is poorly developed in the Pacific, partly because of the lack of rich enough grazing and partly because few of the native peoples have welcomed milk in their diet. Nevertheless, some 10,000 head of dairy cattle are kept in the Hawaiian group, and in Fiji there is a flourishing dairy industry which supplies all the colony's needs for butter and much of the *ghee* consumed by the Indian population.

Horses and mules are used in some numbers in most groups as pack and draught animals; they are most numerous in the ranching areas. Sheep are kept only in small numbers, mainly in Hawaii and the southernmost islands where climate and pasturage conditions are more suitable. Such dry grassy uplands as are found in Eromanga suit them. Goats in small numbers provide meat for planters in most groups and for Indian farmers in Fiji. They were also introduced early to such marginal islands as the Kermadecs and the Galápagos, where they have run wild and destroyed much of the native vegetation. Pig-keeping is still largely in the hands of the native peoples, who also hunt the pigs which have run wild on many islands.

Forestry

The forests of the high islands have hitherto been little exploited, mainly owing to their mixed character (pp. 168–75) and to lack of transport facilities. In many groups small sawmills have been set up to meet the needs of the local settlers, but the islands have relied mainly on external sources for their timber. But now that Australia and New Zealand have drawn heavily upon their own lumber resources, these Dominions are showing an interest in the forests of the islands, particularly in such trees as kauri pine, casuarina and ebony. Since 1925 a firm with Australian capital has been exporting large quantities of kauri from Vanikoro in the Santa Cruz group. Extensive timber concessions have also been granted to another Australian firm in Fiji. New Guinea, too, has developed a timber export, largely of New Guinea walnut, to Australia, the United States and the United Kingdom. In New Caledonia several firms have been engaged in lumbering for many years. Kauri, the New

Caledonian pine, and various hardwoods are the chief types exploited. Much of this is exported to Australia.

Minor forest products including gums, resins, rattan and wild rubber are collected in small quantities by natives in the Territory of New Guinea and in Papua and to a less extent in the other Western Pacific territories. Collection and export of the seed of the Kentia palm (*Howea Belmoreana*) forms the main industry of Lord Howe island.

Marine Products (Plates 161–2)

The marine resources of the Pacific islands tend to be neglected by their inhabitants. They still furnish appreciable quantities of food to the native peoples but the amount is less than formerly, owing to the increasing popularity of imported canned fish. The raw materials of marine origin—mother-of-pearl, turtle shell, clam shell, etc.—are now less in demand locally owing to the decay of native crafts; and, although considerable quantities of pearls and pearl shell of several species (Plate 161) are exported, market demand is very unsteady and is liable to diminish with the rise of the cultured pearl industry and the substitution of plastics for many articles formerly made of pearl shell. *Bêche-de-mer* is still collected in small quantities for export to China.

Full exploitation of the marine resources by modern methods has been developed only in the Japanese mandated islands, where the industry is largely in the hands of Japanese and is under close government supervision. Fishermen's purchases of power boats, gear and processing plant are subsidized. Pearl shell and dried bonito form the bulk of the exports, which go to Japan. The cultured pearl industry has also been established there. Modern methods of fishing are also practised in Hawaii, where power boats are used to catch tunny and other fish. A large proportion of the tunny catch is canned.

Industries

Industry in the Pacific islands has hitherto been very slightly developed, and where it exists is to a large extent concerned with the processing of local products for export rather than with the manufacture of goods for local consumption. Thus in Hawaii and Fiji large quantities of sugar are refined and pineapples are canned; there is also a small pineapple cannery in Tahiti, and considerable

quantities of meat are canned in New Caledonia. In New Caledonia nickel ore is refined in blast furnaces. Wherever timber production is carried on, as in New Caledonia, Fiji or New Guinea, sawmilling is an industry of some importance. In Papua and the Territory of New Guinea six factories have been set up to produce desiccated coconut for export.

The most widespread type of manufacturing to supply the local market is boat-building, which is carried on in all the major ports of the Pacific. In the larger ports such as Honolulu, Suva, or Noumea, marine engines for small craft are constructed by local shipbuilding and engineering firms. In many centres such work is done by the local public works departments as well as by private firms. Whaleboats, cutters and schooners, and launches with auxiliary engines, are the main types produced. In Hawaii the local engineering industry has developed in other directions as well; much of the machinery used in the sugar refineries is made locally.

TRADE

By the end of the nineteenth century, trade had taken on many of its present-day characteristics. The scattered distribution of European and native centres of production has made necessary a series of easy stages in the handling and transport of both exports and imports. Much of this local trade was, and in some areas still is, carried on by traders with schooners and small powered vessels. In the nineteenth century such trade was generally carried on by private individual traders who voyaged among the islands collecting coconut oil, copra, pearl shell and other native-produced commodities, exchanging for these the stock lines of 'trade' goods—hatchets, knives, calico, cheap jewellery and other small goods. As conditions became more settled, many of these men opened stores on the islands and often combined trading with copra production. Lack of currency frequently resulted in the trade being carried on in terms of coconuts or tobacco. The native customers of the store would pay for their purchases with nuts which the store-keeper would convert into copra.

By the beginning of the present century much of this trade had passed into the hands of large companies such as Burns, Philp and the Deutsche Handels- und Plantagen-Gesellschaft, which owned not only plantations but also chains of these local stores linked with large stores or depots in the main ports and population centres.

But by this time the strictly 'native' trade of these concerns had been eclipsed in value by the exports and imports of the plantations and mines with whose interests those of the trading companies were so often linked.

Total External Trade

Some idea of the commodities imported and exported by the Pacific islands will already have been gained from earlier sections of the present Chapter. The quantity of exports relative to world production is in some instances considerable. Thus the 1,000,000 (approx.) tons of copra and other coconut products worth about £2,400,000 represents about 13% of world production. The 1,000,000 tons of phosphate worth about £800,000 is about 8% of the world total of natural phosphate. New Caledonian nickel and chrome output similarly represent nearly 7% and 5% of world production respectively. The significance of these totals in terms of world trade is affected by many economic and political factors, some of which are discussed below. The general trends of trade over the period 1913–38 are shown in Table I. This makes no allowance for year-by-year variations in the rates of exchange. Thus, the increase in trade in French territories in the year 1937 is more apparent than real, being caused by the devaluation of the franc. Nor is any allowance made for the devaluation (p. 521) of the currencies of Fiji, New Zealand or Australia relative to sterling. Fig. 115, showing total trade for the years 1913, 1931 and 1938, is calculated on a sterling basis so that comparisons between different years and different territories can be made.

It will be seen from Table I that most territories maintain a favourable balance of trade. The great excess of imports over exports in Guam and American Samoa can be explained by their use as United States naval bases; stores imported for naval use go to swell the total of imports. The value of the main export commodities in thousands of pounds sterling in the year 1938 is shown in Table II. In most territories the export trade consists of agricultural produce; only in New Caledonia and Nauru do mineral products predominate. Marine products are exported in any quantity only from Hawaii and the Japanese mandated islands.

The destinations of exports depend to some extent on the trade policies of the controlling Powers but to a very large extent are free from political control and depend on purely economic factors such as competition with other areas of tropical production, labour

costs and on comparative costs of transport to markets. Of fundamental importance is the fact that the Pacific islands region has not a monopoly of any of its major resources. Thus, copra, coffee, cocoa, nickel, and chrome are produced in many other parts of the world, often at less cost and generally in areas nearer to the main markets for these products. Australia, New Zealand, China, Japan and the American countries by their proximity to the islands would

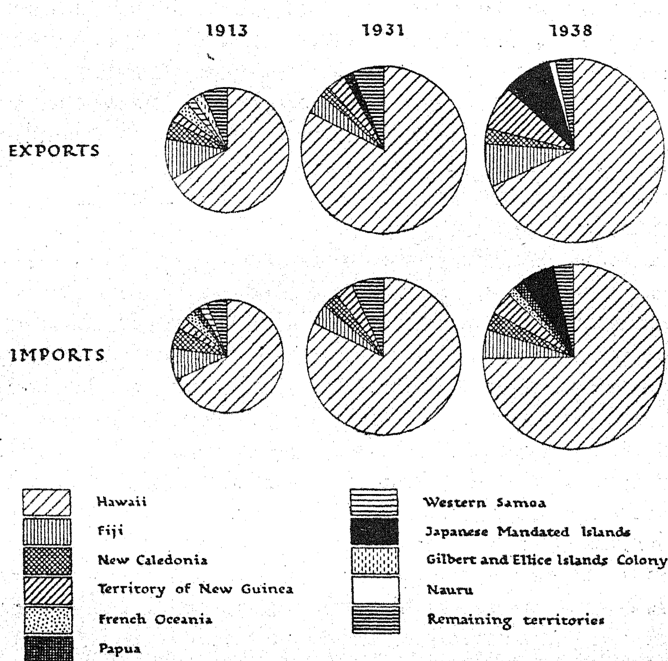

Fig. 115. External trade of Pacific island territories
The trade of all the territories has been calculated on a sterling basis. The area of a circle is proportional to total trade. Based on various sources.

appear to constitute the most advantageous markets. But the relatively small population and recent development of industries in Australia and New Zealand have prevented them from absorbing a high proportion of exports from the islands. The populous and highly industrialized western European countries therefore provide a major market for Pacific products. Australia and New Zealand between them can absorb only a fraction of the copra produced in the Pacific, with the result that the majority of this product goes to Europe, the United States and Mexico. Australia produces much

sugar and large quantities of bananas and so is unwilling to take either of these from the islands. New Zealand absorbs as large a quantity of tropical fruits and vegetables as the population will allow. With minerals, the situation is very diffierent. The development of gold mining and phosphate extraction in the islands has been largely dependent on Australian capital, and Australia absorbs a high proportion of the gold and phosphate.

Imports are so diversified that only their total values can be tabulated (Tables I, III). Their nature depends to a very large extent on the composition of population and the type of productive organization in any territory. In such predominantly 'native' territories as the Cook islands or French Oceania, imports are dependent in quantity on the level of exports produced by native methods of production, and in their nature on native scales of preferences. In such areas, imported kerosine, matches, soap, metal tools and cloth goods are considered necessaries by the native population. Asiatics, such as the Indians in Fiji or the Chinese and Japanese in Hawaii, as a rule retain many of their ancestral preferences in consumption goods. And though they have partly met their needs by producing locally some of their traditional foodstuffs, such as rice and the spices used in curries, they seldom grow sufficient to meet all their needs. Rice, in particular, is imported in considerable quantities into all the territories with large Asiatic communities. It also forms a staple food for native plantation labourers.

In the case of imports for Europeans, a clearer distinction can be made in terms of consumers' and capital goods. Among the former, temperate-zone foodstuffs, alcoholic liquors, and tobacco figure prominently. Among raw materials and capital goods, tools and materials for mining and plantation agriculture, copra sacks, cement, timber, motor vehicles and petroleum products are some of the most important items.

Australia and New Zealand between them supply the bulk of the foodstuffs imported into the islands. Cloth comes largely from the United Kingdom and Japan. Wines come in some quantity from France, and tobacco from the United States. Machinery, tools and other hardware come from the major industrial countries. The United Kingdom, the United States, France and Australia probably supply the most. Motor vehicles are imported mainly from the United States, Canada, and the United Kingdom. Petroleum products come from the United States and the Netherlands East Indies.

National Trade Interests

Presentation of national trade trends for the Pacific is made difficult by the uneven quality of the statistics of the various territories. Thus, in many cases, exports to Europe are undifferentiated by countries. The result is seen in Table IV where a question-mark shows when trade with a particular European country appears to exist, but its quantity is unknown. Considering the Pacific in terms

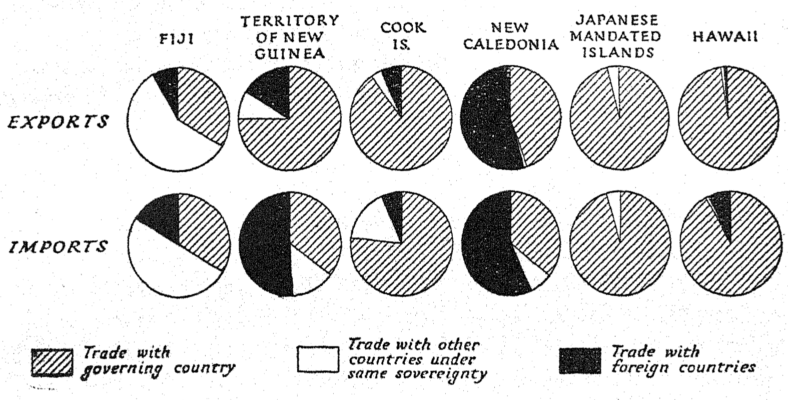

Fig. 116. National trade interests in certain territories in 1938
Based on F. M. Keesing, *The South Seas in the Modern World*, table VIII, p. 343 (London, 1942).

of individual territories (Fig. 116) trade is to a large extent canalized between territories and their governing powers. The main instances are Hawaii, the Japanese mandated islands and the Cook islands. And in terms of total value the trade of these three groups constitutes more than three-quarters of the total Pacific trade. The trade of Hawaii has been closely linked with that of the United States ever since the Reciprocity Treaty of 1875 (vol. II, pp. 319–20); and, since annexation in 1898, Hawaii has been included within the United States tariff system. Trade between the mandated islands and Japan has been intensively developed as fundamental to her exclusive economic policy. In the Cook islands, the New Zealand government has assisted in the marketing of produce; the Dominion accepts imports on a quota basis.

In the other territories, the economic and environmental factors already noted combine to maintain trade on a cosmopolitan basis. Economic ties with the controlling Powers, though not so close or so

assiduously fostered, nevertheless exist. In British territories, since the Ottawa conference of 1932, Imperial preference has been maintained by differential import duties. Australia, though loth to allow imports to compete with her own tropical agriculture, has done much to foster trade with her own dependencies. Thus, the cultivation of many crops in Papua and the Territory of New Guinea is stimulated by bounties paid on products intended for Australian consumption. One result of this policy is seen in the fact that Papua alone of Pacific rubber producers maintained her production throughout the slump in prices between 1930 and 1939. French policy, in contrast to British, has attempted to keep trade within the empire by reducing the export duties on goods destined for French markets.

Internal Trade

Although the native economic system is usually described as of a subsistence type, considerable internal trade takes place. Particularly in the New Guinea area, long trading voyages are still made between distant communities.

Few natives anywhere have become traders or shopkeepers in the European sense; the impersonal cash basis of modern economic systems is foreign to peoples whose economy is highly 'personal', with rights and obligations regulated by kinship. The few government-sponsored attempts to introduce co-operative marketing to native communities have had only limited success.

Mixed-bloods, however, take a significant part in trading in some areas, such as the New Hebrides and Western Samoa. Possessing much the same attachment as the native inhabitants to the place in which they have spent their lives, while at the same time sharing something of the European interest in commerce, they have tended to become small-scale traders or local agents for the larger firms. In other areas, including Fiji and Hawaii, small traders are more often Asiatic. The direct share taken by Europeans in this class of trade is a diminishing one. Europeans engaged in trade are increasingly employed in the larger firms and in the major settlements.

The main population centres of the more developed territories, such as Honolulu in Hawaii, Suva in Fiji, Papeete in Tahiti, or Noumea in New Caledonia have large shops and stores selling a wide range of goods. Many of these are run by the big trading firms which established themselves during the last century. In addition,

there are numerous smaller stores run largely by Asiatics. Fiji also has bazaars run by and for the Indian population. The small stores often to be found in native villages are generally kept by Chinese or Indians. The European owners of the larger plantations frequently maintain stores to supply their indentured labourers. On expiry of indenture, a labourer often spends a high proportion of his accumulated wages on trade goods. At such times quite costly articles like bicycles, perambulators and sewing-machines are purchased.

The local stores, therefore, whether owned by large companies or individuals, thus perform the final stages in the distribution of imports to consumers. They frequently also perform the first stages in the collecting, and sometimes the processing, of goods for export, as when the local store-keeper engages in copra making. The handling in bulk of exports and imports is generally done by the larger firms whose small motor vessels and schooners ply between the main ports and the outlying islands and settlements. The transshipment of goods to and from ocean-going vessels is generally performed at one of the main ports, such as Honolulu, Suva or Papeete. Such small trade as exists between different island groups, centres on these ports. Suva has some trade with the British High Commission territories. Papeete similarly trades with the various groups included within French Oceania.

CURRENCY AND BANKING

American territories use the dollar and French territories the franc. The Japanese mandated islands employ the yen. In British territories the currency situation has been influenced by the close political and trade relations with Australia and New Zealand, whose currencies were devalued by about 25% relative to sterling, the former in 1931 and the latter in 1933. Thus Papua, the Territory of New Guinea, the Gilbert and Ellice islands, Tonga, Norfolk and Lord Howe islands now all use Australian currency, while Western Samoa and the Cook islands and Niue use New Zealand currency. The Solomon islands employ both sterling and Australian currency, and the New Hebrides sterling, Australian currency and the French franc. In the latter territory for some years prior to 1934 a fixed local exchange rate of 124 francs to the pound sterling was maintained, but since then market rates have prevailed. Fiji has its own currency which since 1933–4 has been fixed at the rate of £F111 to £100 sterling.

The 1938 exchange rates used in compiling tables and figures of this chapter were as follows:

£1 (sterling) = £1.255 (Australian)
= £1.246 (New Zealand)
= $4.889 (United States)
= 169.883 francs
= 17.313 yen

Banking facilities are in general poorly developed. Hawaii is, however, well supplied. The Bank of Indo-China has subsidiaries both in French Oceania and New Caledonia. In British territories there are branches of Australian and New Zealand banks; the Bank of New South Wales, for example, has branches in Papua, the Territory of New Guinea, Western Samoa and Fiji. In many territories the governments have established savings banks, usually associated with the local post office; and in the less advanced areas these are generally the only banks existing. Many of the large commercial houses perform banking functions for their customers.

BIBLIOGRAPHICAL NOTE

There are few general surveys of the economics of the whole Pacific islands region. The most up-to-date and useful is that of F. M. Keesing, *The South Seas in the Modern World* (London, 1942). Many of the island groups are dealt with in separate sections in R. W. Robson (editor), *The Pacific Islands Year Book* (wartime edition, Sydney, 1942). Statistical material is provided, for the whole region, in *The Statistical Yearbook of the League of Nations* (Geneva, annually); and, for the relevant parts of it, in: the British Colonial Office, *An Economic Survey of the Colonial Empire (1937)* (London, 1940); the French *Annuaire Statistique* (Paris, annually); the *Annuaire du Commerce Didot-Bottin* (Paris, annually); and the *Blue Books* and other official publications listed in the Bibliographical Notes in the regional volumes of this Handbook.

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COMMERCIAL TABLES

I. *Trends of Commerce*

Territory	Currency*		1913	1920	Annual average, 1921-25
Fiji	£F	Imports	904	1,673	1,157
		Exports	1,426	2,896	1,909
British Solomon Is.	£	Imports	132	181	246
		Exports	110	213	274
Gilbert and Ellis Is. Colony	£ (to 1937) £A (from 1937)	Imports	100†	130	149
		Exports	318	213	327
Tonga	£ (to 1935) £A (from 1935)	Imports	83	384	216
		Exports	82	372	258
Territory of New Guinea	£A	Imports	300†	507	534
		Exports	300†	849	666
Papua	£A	Imports	218	423	384
		Exports	128	270	236
Nauru	£A	Imports	75†	109	80
		Exports	175†	300†	350
Western Samoa	£NZ	Imports	284	561	312
		Exports	255	387	327
Cook Is. and Niue	£NZ	Imports	124	198	145
		Exports	120	108	130
New Hebrides	£	Imports	100†	159	128
		Exports	122†	245	225
New Caledonia	F	Imports	17,708	47,472	62,195
		Exports	15,838	43,043	38,929
French Oceania	F	Imports	9,030	15,000†	28,550†
		Exports	11,555	20,000†	36,350†
Japanese Mandated Is.	Yen	Imports	1,000†	973	2,228
		Exports	2,000	2,180	3,125
Hawaii	$	Imports	37,520	86,337	74,514
		Exports	43,472	195,821	108,097
Guam	$	Imports	160	356	594
		Exports	37	50	73
American Samoa	$	Imports	138†	225	201
		Exports	132†	98	122

Based on F. M. Keesing, *The South Seas in the Modern World*, pp. 318-9 (London, 1942).

(*thousands of currency units*)

Annual average, 1926-30	1931	1932	1933	1934	1935	1936	1937	1938
1,376	930	857	1,069	995	1,257	1,502	1,761	1,675
1,340	1,000	1,699	1,726	1,456	1,811	2,135	2,214	2,535
274	215	157	168	159	146	151	198	233
419	304	177	190	112	94	198	331	292
146	194	115	118	94	117	129	119	207
359	253	259	398	260	340	360	450	351
189	81	86	86	49	69	92	137	83
243	91	96	114	78	91	117	165	98
758	783	779	919	933	953	1,424	1,312	1,611
1,160	919	1,109	1,581	1,766	2,341	2,573	3,420	2,980
413	240	222	218	221	269	318	452	631
423	274	269	276	249	295	355	524	436
134	109	96	98	98	169	155	144	272
366	240	466	437	471	474	470	514	547
304	165	151	151	93	136	167	268	196
331	194	183	174	128	189	263	352	249
133	81	78	90	75	77	97	116	91
147	87	87	86	72	66	91	110	88
267	80	82	86	76	115	124	153	112
331	122	79	72	50	131	122	149	120
150,097	86,701	48,174	56,999	52,379	53,378	59,042	102,622	158,571
89,832	59,086	40,484	47,999	46,677	54,027	54,873	104,292	146,453
49,434	26,187	24,718	19,471	20,133	24,503	36,471	53,285	63,241
47,501	24,396	21,011	14,753	16,879	25,674	38,968	54,174	47,647
5,148	5,939	6,588	8,990	12,969	15,221	19,081	23,265	30,658
8,279	12,800	13,898	18,695	18,424	26,374	25,260	38,252	46,923
89,454	86,957	63,630	66,128	69,234	84,553	92,444	113,975	109,479
92,980	102,738	83,448	92,953	95,830	100,034	127,177	132,240	98,086
608	579	457	379	439	638	780	858	635
212	82	50	62	31	124	137	228	150
230	148	130	127	125	137	188	217	194
130	60	29	22	25	91	57	115	103

* Abbreviations used are as follows: £, £ (*sterling*); £A, £ (*Australian*); £NZ, £ (*New Zealand*); £F, £ (*Fijian*); $, *U.S. dollar*; F, *French franc*; Y, *yen*.

† Estimate from nearest available figures.

II. *Value of Domestic Exports*, 1938 (*in thousands of pounds sterling*)

	Total domestic exports	Coconut products	Sugar-cane products	Coffee	Cocoa	Fruit and vegetables	Other agricultural produce	Metals (gold, nickel, etc.)	Phosphate	Marine products	Forest products	Live-stock products	Native craftwork	Unclassified
Fiji	2,215	244	1,206	—	—	70	M	632	—	3	8	5	M	49
British Solomon Is.	292	259	—	—	—	—	—	—	—	17	12	—	—	—
Gilbert and Ellice Is. Colony	280	43	—	—	—	—	—	—	237	—	—	—	—	—
Tonga	77	72	—	—	—	3	M	—	—	M	M	M	M	2
Territory of New Guinea	2,375	736	—	1	4	—	M	1,617	—	12	7	—	—	M
Papus	347	—	—	—	—	—	—	—	—	—	—	—	—	—
Nauru	436	—	—	—	—	—	—	—	436	—	—	—	—	—
Western Samoa	200	82	—	—	48	62	2	—	—	M	—	M	M	4
Cook Is. and Niue	70	9	—	—	—	60	—	—	—	?	—	—	1	1
New Hebrides	120	75	—	13	28	—	1	—	—	1	1	1	—	M
New Caledonia	862	25	—	71	—	—	3	696	—	24	12	27	—	5
French Oceania	274	149	M	2	—	?	70	—	42	5	M	—	—	7
Japanese Mandated Is.	2,709	115	1,531	M	—	M	35	?	191	214	—	—	—	624
Hawaii	20,045	—	10,697	143	—	7,956	20	—	—	327	—	41	—	859
Guam	31	30	—	—	—	—	—	—	—	—	—	—	1	—
American Samoa	21	11	—	—	—	—	—	—	—	—	—	—	1	—

M indicates minor trade

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 320 (London, 1942).

III. *External Trade*, 1938 (*£ sterling*)

Territory	Total Trade				Imports				Exports			
	Total		Per Capita		Total		Per Capita		Total		Per Capita	
	Value	Position	Value	Position	Value	Position	Value	Position	Value	Position	Value	Position
Fiji	3,793,000	3	18·0	5	1,509,000	3	7·2	6	2,284,000	4	10·8	5
British Solomon Is.	525,000	9	5·5	11	233,000	8	2·4	13	292,000	8	3·1	11
Gilbert and Ellice Islands Colony	447,000	10	12·5	6	166,000	10	4·6	8	281,000	9	7·8	6
Tonga	145,000	14	4·3	14	66,000	15	2·0	15	79,000	13	2·4	13
Territory of New Guinea	3,673,000	4	6·5	9	1,289,000	4	2·3	14	2,384,000	3	4·2	9
Papua	854,000	6	3·1	15	505,000	6	1·8	16	349,000	7	1·3	16
Nauru	655,000	7	191·4	1	218,000	9	63·7	1	437,000	6	127·7	1
Western Samoa	358,000	11	6·2	10	158,000	11	2·7	11	200,000	11	3·5	10
Cook Is. and Niue	144,000	15	8·8	7	73,000	14	4·4	9	71,000	14	4·4	8
New Hebrides	232,000	12	5·3	12	112,000	13	2·6	12	120,000	12	2·7	12
New Caledonia	1,795,000	5	33·8	4	933,000	5	17·6	3	862,000	5	16·3	4
French Oceania	646,000	8	14·7	6	372,000	7	8·5	5	274,000	10	6·2	7
Japanese Mandated Is.	4,516,000	2	37·3	3	1,785,000	2	14·7	4	2,731,000	2	22·5	3
Hawaii	42,455,000	1	103·2	2	22,393,000	1	54·3	2	20,063,000	1	48·8	2
Guam	161,000	13	7·2	8	130,000	12	5·8	7	31,000	15	1·4	15
American Samoa	61,000	16	4·7	13	40,000	16	3·1	10	21,000	16	1·6	14

Based on F. M. Keesing, *The South Seas in the Modern World*, p. 317 (London, 1942).

IV. *National Trade Interests*, 1938 (*in thousands of pounds sterling*)

		Total	United Kingdom	France	U.S.A.	Canada	Australia	New Zealand	Japan	Other countries
Fiji	Imports	1,509.4	500·0	?	116·5	91·9	452·7	46·3	38·3	263·7
	Exports	2,215·1	742·2	—	68·0	497·5	690·0	92·7	—	118·8
British Solomon Is.	Imports	232·9	32·3	—	12·7	4·0	120·0	2·0	10·0	51·9
	Exports	292·4	?	—	—	—	168·8	—	—	123·6
Gilbert and Ellice Is. Colony (1937)	Imports	95·4	24·8	?	7·6	?	41·9	3·4	4·8	12·9
	Exports	359·9	6·2	—	20·2	—	197·3	70·9	42·7	22·6
Tonga	Imports	66·2	12·4	—	5·7	3·4	16·4	13·6	6·2	19·8
	Exports	77·5	?	—	—	—	?	2·8	?	74·7
Territory of New Guinea	Imports	1,288·7	127·4	3·1	347·3	11·7	459·1	1·6	78·8	259·7
	Exports	2,384·3	138·0	13·2	—	—	1,790·8	—	6·9	435·4
Papua	Imports	505·2	70·3	—	71·8	?	244·7	?	15·1	103·3
	Exports	348·5	26·1	—	M	—	282·3	—	4·4	35·7
Nauru	Imports	217·8	67·6	0·2	11·9	1·3	100·3	4·9	M	31·6
	Exports	437·4	8·2	—	—	—	326·0	99·3	—	3·9
Western Samoa	Imports	158·4	23·9	?	15·7	13·2	22·6	47·5	11·8	35·5
	Exports	200·0	68·5	—	20·2	?	0·6	64·8	—	45·9
Cook Islands	Imports	60·3	6·0	—	2·0	0·2	3·5	46·2	1·5	0·9
	Exports	59·0	1·8	—	3·9	—	—	53·3	—	—
New Hebrides	Imports	111·9	3·1	29·1	8·4	?	54·8	?	7·8	8·7
	Exports	120·2	—	117·7	—	—	1·3	—	—	1·2
New Caledonia	Imports	933·6	7·1	332·0	42·5	?	282·5	16·5	48·4	204·6
	Exports	862·8	?	386·1	70·6	?	24·8	—	21·2	359·6
French Oceania	Imports	370·2	21·2	106·0	108·3	—	46·0	27·2	?	61·5
	Exports	274·3	?	212·0	17·7	—	7·7	2·4	34·2	0·3
Japanese Mandated Is.	Imports	1,772·2	—	—	—	—	—	—	1,686·6	80·9
	Exports	2,708·9	—	—	—	—	—	—	2,616·5	122·8
Hawaii	Imports	22,397·1	40·9	61·3	20,699·5	286·3	M	61·3	613·6	623·3
	Exports	20,065·4	102·3	M	19,758·6	40·9	20·4	M	20·4	122·8
Guam	Imports	129·8	?	—	59·5	—	—	—	14·4	55·9
	Exports	30·7	—	—	24·7	—	—	—	4·3	1·7
American Samoa	Imports	39·7	0·6	—	13·4	—	19·1	19·1	4·8	1·8
	Exports	21·0	—	—	21·0	—	—	—	—	—

M indicates minor trade of unspecified value.

Based on F. M. Keesing, *The South Seas in the Modern World*, table facing p. 384 (London, 1942).

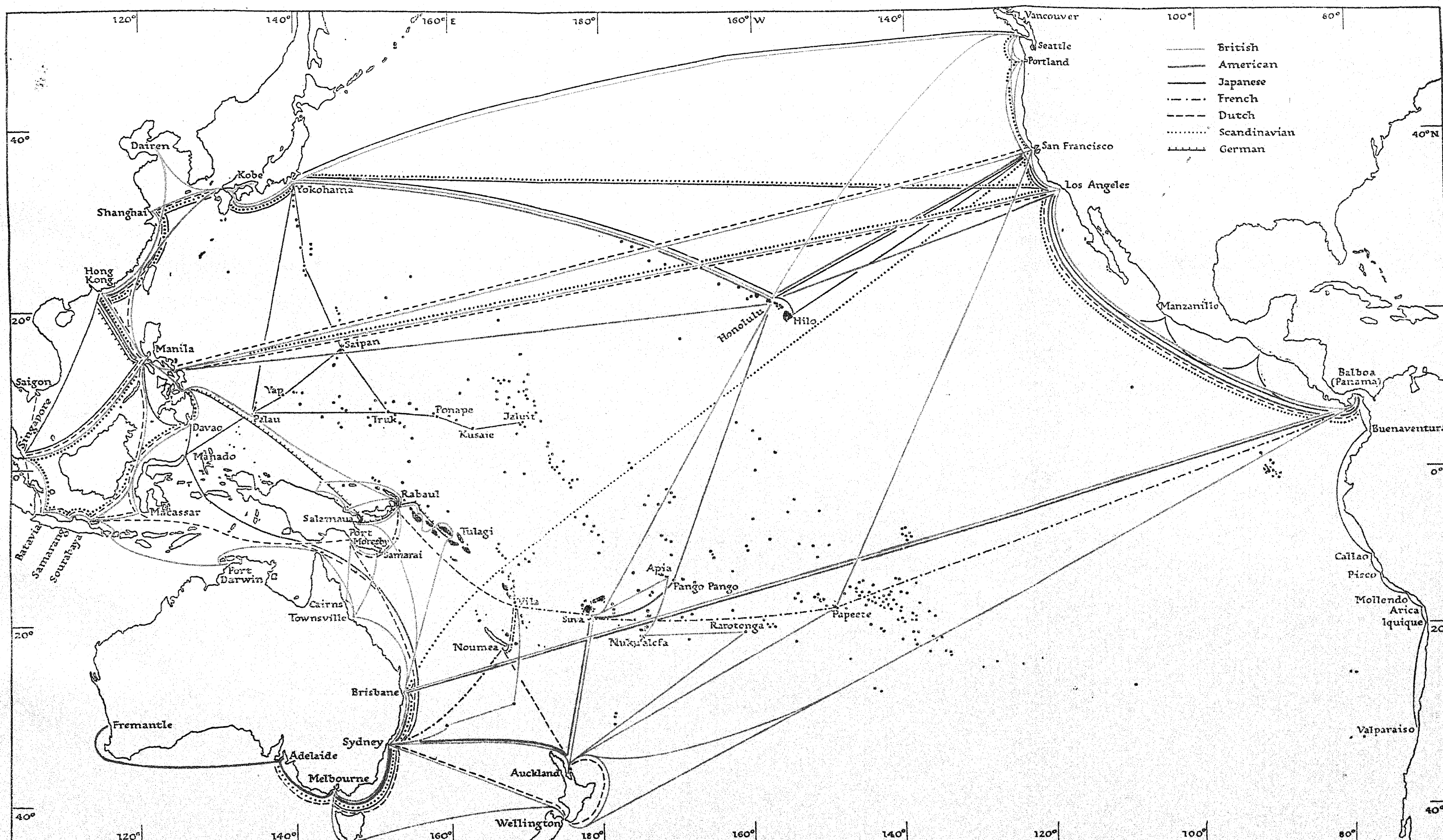

Fig. 117. Shipping routes in the Pacific, showing national interests
This map shows the nationality of vessels operating on the principal routes in 1938–9. Based on various sources.

Chapter XVI

COMMUNICATIONS

Sea Communications : Air Communications : Land Communications : Signal Communications : Bibliographical Note

The Pacific is a region of vast distances ; and, despite the great number of islands which it contains, the traveller may pass over it for thousands of miles without seeing land. From the point of view of communications it has always been thought of in modern times primarily as a barrier dividing the Americas from the continent of Asia and the lands to the south of it. As a result of the need to break the ocean crossing into a series of shorter stages, where possible, many islands—often barren and in other respects worthless—have become important as coaling stations, cable stations, and, most recently, as refuelling bases for aircraft. There are great stretches of ocean, however, unbroken even by the smallest island or rock. Ships bound from New Zealand to Panama are three weeks at sea and often are at no time within sight of land. Aircraft travelling from California to Hawaii cover over 2,000 miles without a chance of refuelling. The longest stretch of submarine cable in the world is that between Banfield (Vancouver) and Fanning island. These great distances have in many ways increased the cost of providing trans-Pacific communications. The economic problem is further intensified by the smallness of the contribution which can be made to the revenue of the services by the islands which they use. Where these islands have little other importance, as with Midway, Wake, Fanning and Canton, the organizations using them not only receive no local revenue at all but have to bear the cost of providing the amenities of civilized life for their employees and of supplying them regularly with necessary stores. In the larger islands the situation is somewhat different, but the possibilities of local revenue are generally of only minor account. It was once widely believed, for example, that the opening of the Panama Canal would greatly increase the shipping of Papeete. In fact, however, the companies running shipping services from Panama to Australia and New Zealand have never regarded the slightly lengthened voyage which a call at Papeete would involve as worth while. Only Hawaii is sufficiently developed to make any very full use of the major trans-oceanic services.

The Pacific islands have thus largely to rely for communications on ancillary services. Relatively small steamers and sailing vessels provide for the transport of passengers and cargo; and wireless, in the absence of cables, provides signal communication. The same factors—smallness of resources and of population—have limited the development of communications within the islands. In only a few areas are there well-developed road systems, and there are few railways. Except in the largest islands, however, land communication has been less important than in most other parts of the world. A very large proportion of the population of the Pacific islands lives within a few miles of the sea. Thus canoes have been among the most highly prized possessions in nearly all native communities (pp. 427–31), and in modern times schooners and launches have come into widespread use among government officials, missionaries, traders and others.

SEA COMMUNICATIONS

Shipping in the Pacific, as in other areas, may be divided into two broad classes—services operating to definite and regular schedules and unscheduled services. The first class (Fig. 117) includes trans-oceanic services, services between mainland ports and island dependencies, and inter-island services in the more developed areas. The second class comprises mainly ordinary tramp shipping, the specialized cargo services maintained by oil, phosphate, sugar and other interests, and a large amount of inter-island traffic often maintained by sailing craft.

Trans-oceanic Services

Before the war the densest traffic was on the north Pacific routes; the scheduled services amounted to about 3,500,000 traffic-tons* a year (Fig. 118). This was made up of the important services between the principal North American and Asiatic ports bordering the Pacific and of through services from eastern America, Europe or elsewhere (including several round-the-world services). The main passenger services were those of the Canadian Pacific line (British,) the American President line (American), and the Nippon Yusen Kaisha (N.Y.K.) line (Japanese). The Canadian Pacific line maintained a fortnightly service between Vancouver and Yokohama;

* 'Traffic-tonnage' represents the average gross tonnage of vessels employed on a particular service multiplied by the number of scheduled voyages.

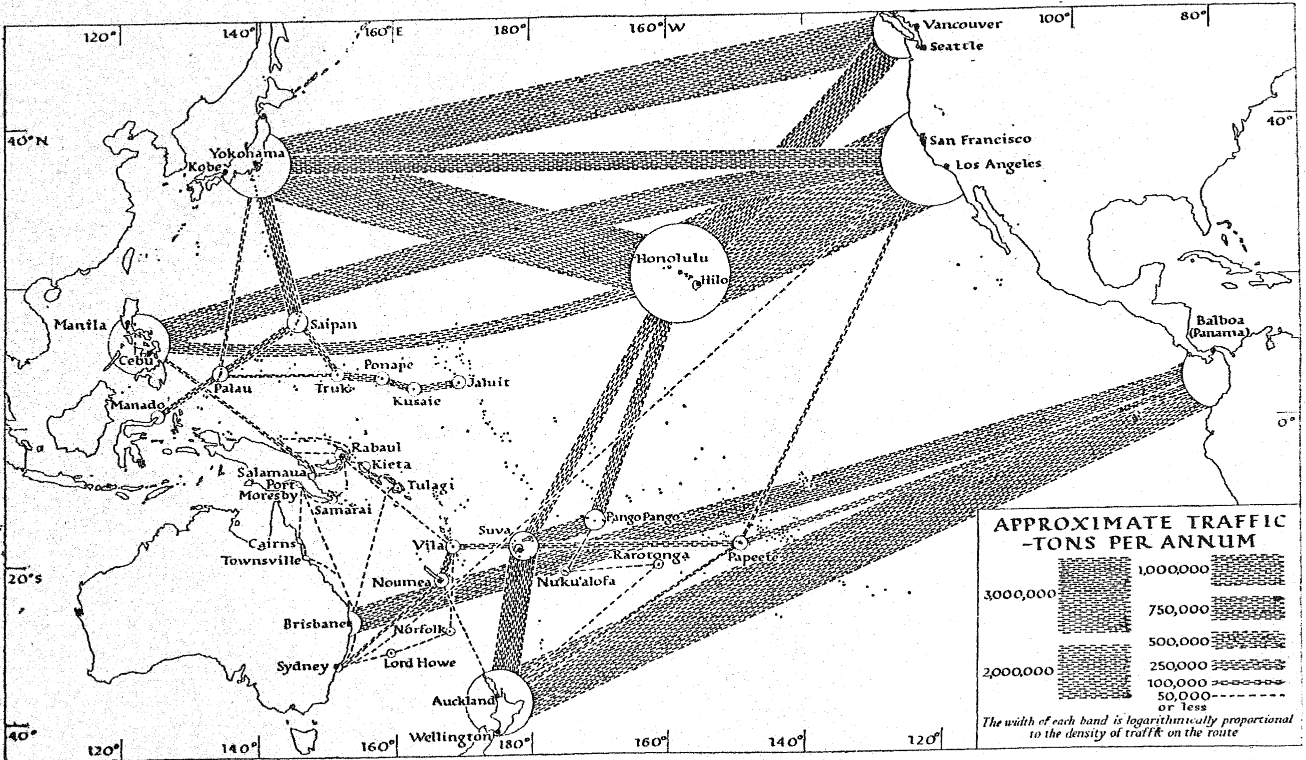

Fig. 118. Density of traffic on Pacific shipping routes

This map shows the density of traffic in 1938. For explanation of the term 'traffic-ton', see p. 530. Based on various sources.

alternate vessels called *en route* at Honolulu. Four ships of between 16,000 and 26,000 tons were employed. The N.Y.K. line also maintained a service between Yokohama and Vancouver, from which port they proceeded to Seattle, and in addition ran a service from Yokohama to Californian ports, *via* Honolulu, at fortnightly intervals. Ships were of the same general type as those of the Canadian Pacific line. The American President line maintained services between California and both Yokohama and Manila, *via* Honolulu. This company used several vessels with accommodation for about 700 passengers and with only limited cargo space and others with greater cargo space and accommodation for about 100 passengers. In addition there were a number of services in the north Pacific mainly concerned with the carriage of freight. These employed rather smaller ships. For example, the Blue Funnel line service from Seattle and Vancouver to Hong Kong, *via* Yokohama and other intermediate ports, was maintained by vessels of about 10,500 tons, with accommodation for a few passengers; the Blue Funnel round-the-world service, calling at Los Angeles, Manila, Hong Kong, Batavia and other ports, employed vessels of about 7,000 tons; and the Maersk line, operating a service between New York and the Philippines, *via* Los Angeles, Yokohama, Hong Kong and other ports, used ships of 5,000 tons or less, equipped with deep oil tanks and some refrigerated space.

In the south Pacific the most important trans-oceanic services were those from ports in the United Kingdom, *via* Panama or cape Horn, to Australia and New Zealand. On these routes a number of British lines operated—the Shaw, Savill and Albion Company, the New Zealand Shipping Company, the Federal line, the Port line, and the Blue Star line. Ships varied in size from about 8,000 to 17,000 tons and in speed between 13 and 16 knots. The larger ships of the Shaw, Savill and Albion and New Zealand lines were mainly passenger-and-cargo vessels, with accommodation for from 100 to 500 passengers. Ships of the other companies were primarily cargo vessels, though many carried up to a dozen passengers. Nearly all had considerable refrigerated space, and some of the newer ships were specially equipped for the carriage of chilled beef. The French Compagnie des Messageries Maritimes provided a similar link between metropolitan France and French territories in the Pacific. About nine voyages a year were made between French ports and New Caledonia, *via* the French Establishments in Oceania and the New Hebrides.

Another group of services was that from Canada and the United States to Australia and New Zealand, often with intermediate calls at island ports. A mail and passenger service from Vancouver to Auckland and Sydney, *via* Honolulu and Suva, was operated by the British-owned Canadian-Australasian line. Two ships were employed: the *Niagara*, of 13,400 tons, with accommodation for about 500 passengers, and the *Aorangi*, of 17,500 tons, with accommodation for 600 passengers. Both ships had a speed of about 18 knots. They had considerable cargo space, part of which was refrigerated. A similar, and largely competing, service from San Francisco and Los Angeles to Auckland, Sydney and Melbourne, *via* Honolulu, Pango Pango and Suva, was operated by the American-owned Oceanic Steamship Company (a subsidiary of the Matson line). Two modern vessels of 18,000 tons and with a speed of 22 knots were employed. They were of the same general type as the British ships, each with accommodation for about 700 passengers and considerable cargo space. The Union Steam Ship Company of New Zealand formerly maintained a passenger and cargo service from Sydney and Wellington to San Francisco, *via* Rarotonga and Papeete, but this was discontinued after the establishment of the Oceanic line service. In its place the Union line operate a regular cargo service. In addition, there was another cargo service from Vancouver and Californian ports to Brisbane run by the Swedish-owned Trans-Atlantic Steamship Company. There were also several cargo lines running from Australia and New Zealand to United States and Canadian ports on the Atlantic coast.

A fourth, but less important, group of services comprises those from Asiatic and East Indian ports to Australia and New Zealand. Before the war these comprised primarily the Dutch K.P.M. service from Saigon, Singapore and Netherlands East Indies ports to New Zealand and Australia, *via* Port Moresby, Rabaul, Vila and Noumea, and Japanese cargo services.

Services between Mainland Ports and Island Territories

The regular shipping services between mainland ports and the islands fall mainly into three groups: (i) services linking the American mainland with the Hawaiian islands; (ii) services from Australia and New Zealand to the islands of the south Pacific; and (iii) services from Japan to the Japanese dependencies in the north-western part of the Pacific islands region. The route between the Hawaiian islands and California carries almost the heaviest

traffic of any route in the Pacific. Before the war, in addition to the large number of trans-oceanic services which called at Honolulu, there was a weekly passenger cargo service run by the Matson line between the islands and Los Angeles and San Francisco. This run, being between American ports, was regarded as a 'coastwise' one, and it was only open to American vessels to accept passengers and freight for carriage upon it. Services between Japan and the Japanese dependencies were subject to a still narrower restriction. They were operated entirely by the N.Y.K. line, under the protection of a monopoly, and were elaborately planned to assist the economic and strategic development of the islands along the lines laid down by the Japanese government. Services in the south Pacific were much less closely integrated. Travel between neighbouring island groups was in a number of instances impossible, except by way of Australia or New Zealand. The services were operated mainly by Burns, Philp and Company and the Union Steam Ship Company of New Zealand (Plates 163, 164).

In addition to these regular services there were several important services for the carriage of specialized cargoes at irregular intervals. In particular, phosphate vessels sailed from Nauru and Ocean island to Australian and New Zealand ports; and vessels of the Colonial Sugar Refining Company collected cargoes in Fiji for carriage to the company's refineries in Australia and New Zealand.

Inter-island Services

In many island groups there are regular inter-island services. The most highly developed service is that of the Inter-Island Steam Navigation Company in the Hawaiian islands, which is operated by vessels of between 2,000 and 3,000 tons. In Fiji small motor vessels of about 300 tons are used to link the main islands and to provide contact with Rotuma. Similarly in New Caledonia, the Japanese mandated islands, New Guinea, the Solomon islands and the New Hebrides there are more or less regular services, maintained in some instances by trading and plantation interests. In Tonga communication depends largely upon government vessels.

In all parts of the Pacific islands region there are in addition many schooners (Plate 165) and cutters, often with auxiliary engines, and motor launches. In some areas these still provide the main means of communication. Their size is generally very small. At Papeete, for example, local craft numbered 127 in 1939, but their total tonage was only 1,991.

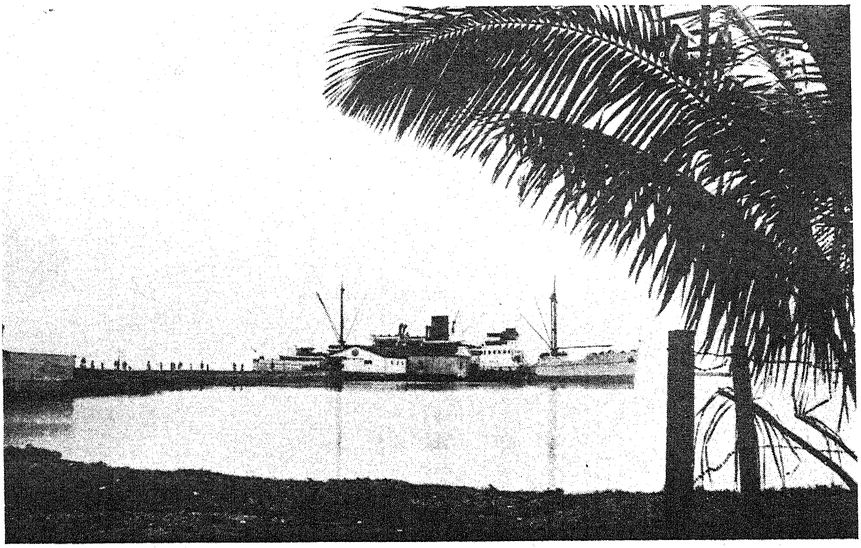

Plate 163. Shipping bananas and copra, Tonga
The ship is the Union Steam Ship Company's M.V. *Matua*.

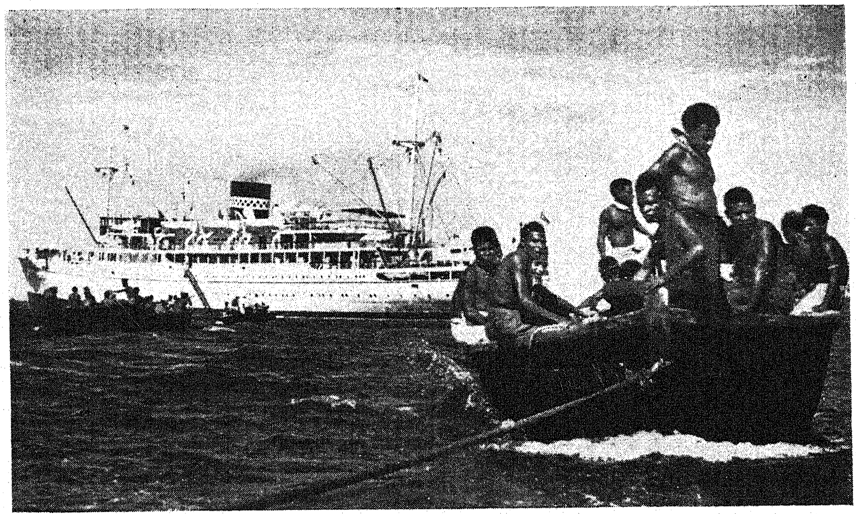

Plate 164. Loading copra in New Guinea
The ship is Burns, Philp and Company's M.V. *Bulolo*. As at many points on the New Guinea coast, and elsewhere in the Pacific, the cargo is taken to the ship by surf-boat.

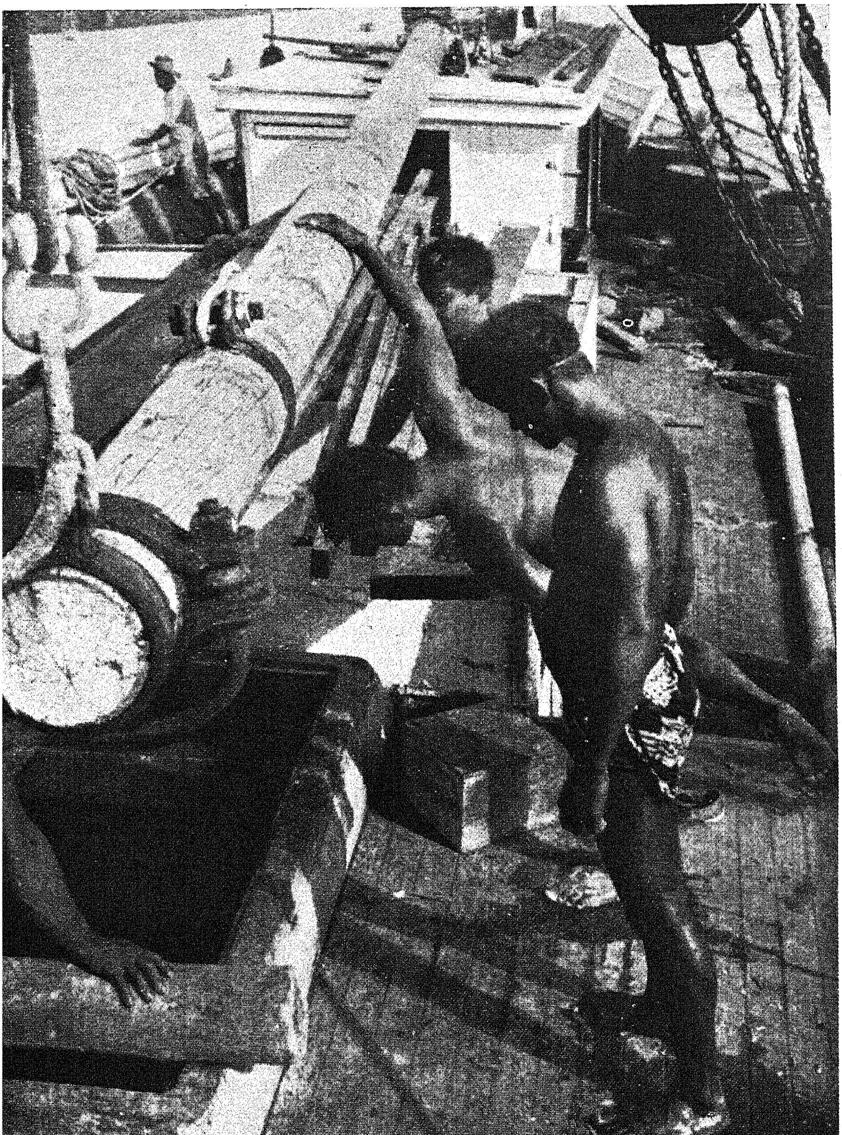

Plate 165. On board a schooner in French Oceania

Vessels such as this continue to play an important part in the trade of the Pacific islands. For over a hundred years Polynesians have served on them, both as officers and as members of the crew.

AIR COMMUNICATIONS

In the Pacific, as in other areas where settlement is widely scattered, the development of air communications is the most important means of destroying isolation. Since the outbreak of war with Japan in 1941 great development has actually taken place, but since it has been organized to satisfy military needs it gives only an imperfect indication of the direction which peacetime organization will follow. Before the war, however, a number of civil air services were already well established. Two trans-oceanic air services were being operated by Pan-American Airways. One ran from San Francisco to Manila and Hong Kong, *via* Honolulu, Midway, Wake and Guam. The other was from San Francisco, *via* Honolulu, to Auckland. Several changes of route were made; that finally chosen was by way of Canton island, Suva and Noumea. Another relatively long-distance route was that of the air mail service from Sydney to Port Moresby, Salamaua and Rabaul. This service was begun in 1938, and it continued in operation till the Japanese invasion. The Japanese also established long-distance services from Yokohoma to Saipan and Palau and from Palau to Dilli, in Portuguese Timor. These services were scarcely beyond the experimental stage at the outbreak of the Pacific war. In a number of areas local services were also either in operation or projected. The most important of these were in New Guinea, where from 1927 onwards they had played an important part in opening up the interior of the country (vol. IV, pp. 246–7). In Hawaii there were also regular services. In Fiji a service was operated for a short time but was discontinued. In the Japanese mandated islands a service was planned shortly before the war to link the principal islands, between Saipan and Jaluit.

It is not only in the operation of regular commercial airlines, however, that the development of air communication promises to be of importance to the Pacific islands. The use of aircraft seems certain, for example, greatly to simplify the administrative supervision of scattered dependencies, as in the Western Pacific High Commission territories; and the proposed use of air-ambulances will bring nearly all suffering from serious disabilities within reach of adequately equipped hospitals.

LAND COMMUNICATIONS

In many parts of the Pacific native peoples built fairly extensive systems of 'roads' when they first came under the influence of Euro-

pean missionaries or administrators. These roads were mainly footpaths or bridle tracks. Many of them were surfaced with crushed coral, sand or mud; and some of them, such as those in the Gilbert islands, have proved suitable for a limited amount of light motor traffic. They cannot stand up, however, to heavy traffic or continuous use. Apart from this, their curves and gradients are frequently too severe. Thus, in the most highly developed areas—notably Hawaii, Fiji and New Caledonia—much money has been spent during the past twenty years in providing an improved system of main roads. In Hawaii many roads have a bitumen surface. In Fiji and New Caledonia surfaces are less good, but the roads stand up to continuous use by heavy trucks. Similarly in the more developed parts of other territories—such as on Tongatapu and 'Uta Vava'u, in Tonga; on Tahiti, in the Society islands; and on Upolu, in Samoa—some roads have been improved to take motor traffic. Over large areas in the Pacific islands, however, there are no public roads of a similar standard, but where there are European plantations—as in New Guinea, the New Hebrides and the Solomons—numerous short stretches of privately-owned roads exist which are regularly used by motor vehicles. Since 1942 much further development has taken place in parts of the Western Pacific which have been the scene of fighting or have been used as bases by the military forces. Road construction undertaken for military reasons will, in many places, be of extreme value when normal conditions are restored.

Railways have never had an important place in the general transport systems of the islands. In the Hawaiian islands both passenger and goods traffic has been steadily decreasing; in New Caledonia the projected west coast railway from Noumea to Bourail has not been extended north beyond Paita (about 18 miles from Noumea). Where railways remain fully in use they are almost invariably specialized systems, designed for the conveyance of some bulky commodity from its place of origin to factories or ports. Such are the railways of the Colonial Sugar Refining Company in Fiji and the phosphate railways of Nauru, Ocean island, Makatea and Angaur.

SIGNAL COMMUNICATIONS

Conditions in the Pacific have, in general, not been conducive to the easy development of postal, telegraph and telephone services.

Submarine cables had been in continuous operation across the Atlantic for over thirty years before the first trans-Pacific cables were laid. The delivery of mails has been limited by the infrequent shipping connections which many islands have had and by the poor anchorages existing in some areas. The procedure followed at Niuafo'ou (' Tin Can Island '), in Tonga, where the mail was thrown overboard in a sealed tin to be collected by swimmers, is well known (vol. III, p. 112). Similarly within the larger islands the generally mountainous nature of the country and the frequent absence of roads has hindered development. Even in some districts of Fiji mail is still delivered by native carriers. Telephone systems generally exist only in the more industrially developed areas and elsewhere only in the immediate vicinity of the main settlements.

Submarine Cables (Fig. 119)

Between 1870 and 1900 a number of important cables were laid on the eastern and western margins of the Pacific. China and Japan, the Netherlands East Indies, Australia and New Zealand were linked with Europe *via* the Indian ocean and the Mediterranean; and the Pacific littoral of South America was similarly linked by way of the Caribbean and the Atlantic. The first cable across the Pacific was not laid, however, until 1902. In that year the Pacific Cable Board, comprising representatives of Great Britain, Canada, Australia and New Zealand, laid a cable from Banfield, on Vancouver island, *via* Fanning island, Suva, and Norfolk island, to Southport, in Queensland, and Doubtless bay, in the north of New Zealand. In more recent years this cable has been duplicated between Banfield and Suva, and a new cable has been laid from Suva to Auckland and from Auckland to Southport, *via* Sydney. The system is now operated by Cables and Wireless, Ltd.

Also in 1902 an American company began the laying of a cable from San Francisco to Honolulu and on to Bacon in the Philippines, *via* Midway and Guam. It was completed in 1903. In 1906 extensions were made to Shanghai and to Chichi shima, in the Bonin islands, where a link was established with a Japanese cable to Tokyo. In 1905 a German company had also entered the field by laying cables from Manado, in Celebes, to Yap, and from Yap to Shanghai, *via* Okinawa, in the Ryukyu islands, and to Guam. Since the Japanese occupation of Yap the cables to Manado and Guam have been allowed to fall into disrepair.

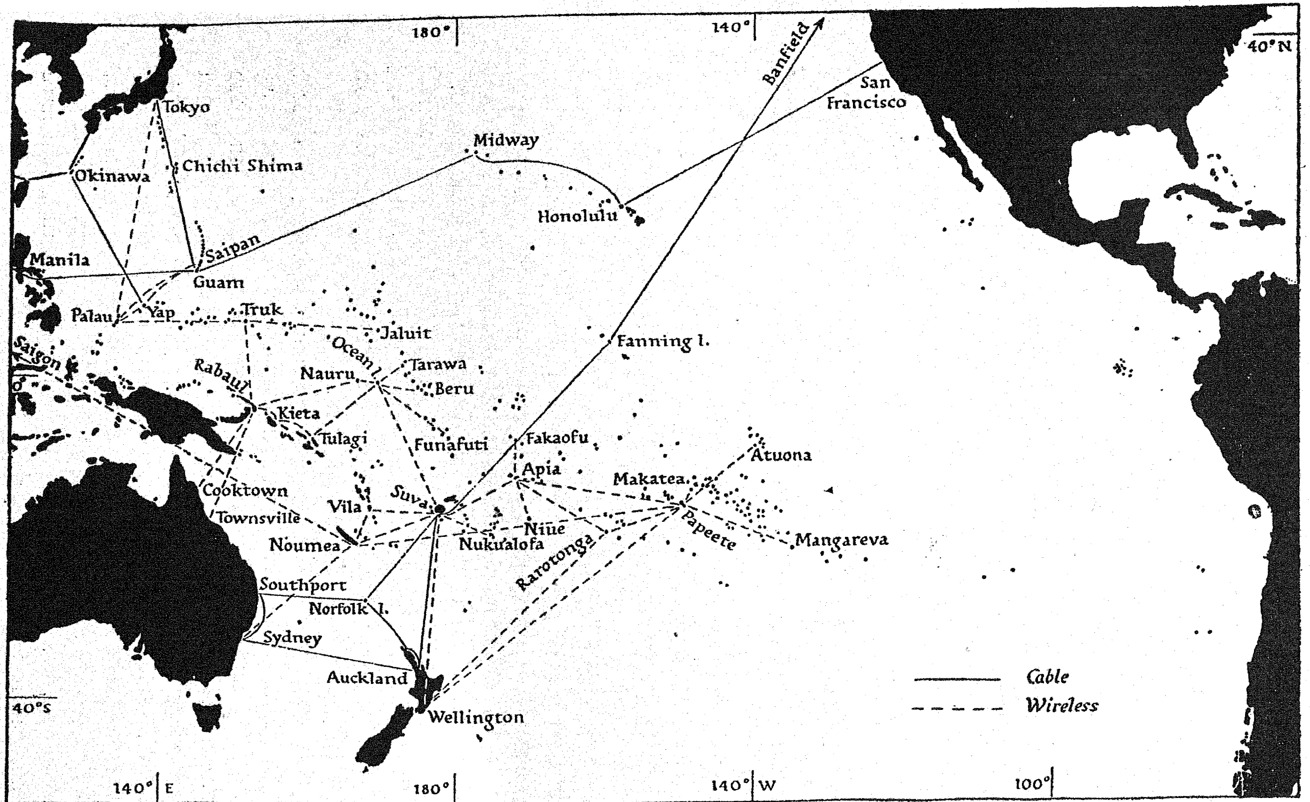

Fig. 119. Cable and wireless communications

This map shows cables and the main outline of the system of wireless communication existing in the Pacific area in 1939. Based on various sources.

Wireless

Except in the few areas served by cables, wireless provides the only means of signal communication between the islands and the outside world. In nearly all territories there is at least one wireless-telegraph station which maintains regular schedules with stations outside the islands. Some details of particular schedules are given in the relevant sections of the regional volumes of this Handbook: ; the broad outlines of these services are indicated in Fig. 119.

Apart from these main stations there are many less important ones, operated by administrative officers, trading companies and individual European settlers. Usually such stations are allowed to communicate only with the main W/T station in their area and, in some cases, with ships. Owing to the general absence of telephone systems the use of wireless in this way was rapidly increasing before the war. In New Guinea it had developed particularly fully. Between 150 and 200 small, semi-portable radio-telephone sets, requiring little skill to operate, were in use in Papua and the Territory of New Guinea. They communicated with central stations at Port Moresby and Rabaul.

The development of broadcasting in the Pacific area has been dealt with elsewhere (Chapter XIV, pp. 486–7).

BIBLIOGRAPHICAL NOTE

Sources of information on communications are mainly of a technical kind, often not readily accessible, and rather scattered. Two more general works of interest are: Will Lawson, *Pacific Steamers* (Glasgow, 1927); and F. J. Brown, *The Cable and Wireless Communications of the World* (2nd edition, London, 1930). A very good general indication of shipping services is given by the *Official Steamship and Airways Guide*, published by Transportation Guides, Inc. (New York, monthly); this is very adequate for American services but somewhat less so for other services. For wireless communications full and accurate information is available in the various publications of the Bureau of the International Telecommunication Union, at Berne.

Appendix I

PACIFIC OCEAN CURRENTS

Figs. 120–1 give a general picture of ocean surface currents in August-September (northern summer, southern winter) and in February-March (northern winter, southern summer). They show *average* conditions with regard to the speed and direction of currents. Degrees of variability are indicated on the charts, but it should be noted that in abnormal seasons directions of currents may vary and may even be reversed, and speeds may differ from the average. This is especially true of the secondary currents south of the equator.

On the whole the currents of the Pacific ocean set with the trade winds and with the westerlies. The wind belts and the doldrums shift latitudinally with the apparent movement of the sun, and the maps show a corresponding southward or northward displacement of the major currents. Deflection of currents by intervening land masses is well marked along the borders of the Pacific, and on detailed charts deflection and dispersal may be observed among islands and through gaps in barrier reefs and atolls.

The Main Currents

Both series of trade winds have an easterly component and in inter-tropical latitudes in the Pacific the greater body of water is thus moving westward. The strongest currents here are the north and south equatorial currents which maintain a generally east-west direction from the American coast to the coasts of New Guinea and Mindanao in the Philippines. The maximum outer limits of these currents are roughly the parallels 20°N and 10°S, and their influence is marked at most points within these limits during part or all of the year. Those areas within these latitudes which are not affected lie within the intermediate belt of water known as the equatorial counter current. This has its greatest development during the northern summer when it affects an area of the ocean's surface twice as great as that which it covers during the northern winter. The counter current derives its water and impetus from waters piled up in the Western Pacific by the equatorial current. The waters return in reverse direction to the American coast. Seasonal shift is characteristic of all the equatorial currents. Only the southern islands of the Carolines and the Marshalls (e.g., Jaluit) lie in the sphere of the equatorial counter current throughout the year.

The north equatorial current contributes to the counter current which adjoins it on the south and also to the Kuro shio (Kuro current). This is a belt of relatively warm water which runs along the east side of the fringe of islands lying off Asia (with minor branches through the straits and seas which intervene between them and the continent), and which turns eastward at the latitude of Honshu to flow eastward towards America, under the influence of the westerlies, as the North Pacific current. A distinct divide exists between the warm waters of the Kuro shio and the cold North Pacific currents. The Oya shio of the north-western sector is the most important of these. The North Pacific current gradually loses heat in mid-ocean and comes to the western shores of the United States as a cool current. Its flow is augmented by cool waters which originate in higher latitudes and flow southwards along the coast of British Columbia. These belts of water form the Californian current which eventually passes into the north equatorial current as a relatively cool and slow-moving body of

water. An easterly stream from the Californian current hugs the lower Californian and (in the northern winter) the Mexican coast, and forms a distinct front against water from the north equatorial current, or, in the northern summer, with the then well-developed equatorial counter current.

The south equatorial current tends to be split up off New Guinea and among the Bismarck and Solomon archipelagoes, particularly in the northern winter. In the northern summer it contributes the major supply of water to the equatorial counter current. For these reasons, and because of more general differences in the configuration of the western borders of the Pacific, there is nothing comparable to the Kuro shio in the south-west sector. The East Australian current, flowing for the most part between the Barrier Reef and the mainland, carries warm waters as far south as cape Howe ($37\frac{1}{2}$°S). It is much more variable than the south equatorial current which feeds it, and is weakest during the southern winter. These waters turn eastwards under the influence of the westerly winds and flow against the west shores of the Auckland peninsula. The western coasts of New Zealand and the east coast of the South Island are influenced by parts of the west-wind drift. This major current flows constantly eastward through the great landless expanses of the south Pacific Ocean and nothing of similar magnitude exists in northern temperate waters. Along the northern limits of the west-wind drift the water tends to flow north-eastwards and its cool waters meet the warmer currents of sub-tropical latitudes along the lines shown on Figs. 120–1. The west-wind-drift waters, together with colder water from higher latitudes, curve northwards up the west coast of South America. Off northern and central Chile the charts show a broad belt of northward-flowing water between the coast and the weak tropical currents. The Peru current, lying close inshore, has a more direct south-north trend, and is cooler than the last-named belt of water. It owes its character to the upwelling of cooler water from greater depths, rather than to an influx of cool waters propelled by the westerlies. Off-shore winds drive the surface waters seaward, and with them the surface currents, and these are replaced by the upwelling cold water. The Peru current feeds the south equatorial current with waters which are very cool for the latitude.

Minor Currents

Between the major surface currents indicated above are large areas of ocean in which the currents are less distinct, more variable and slower in flow. Some details for the island groups described in vols. II–IV are given below. It may be noted here that the essential difference between the ocean circulation north and south of the equator results from the strength of the Kuro shio and the North Pacific current and the absence of a counterpart of their joint flow in similar latitudes in the south Pacific. The result is that whilst the tropical waters of the north Pacific flow from east to west and are linked with the north equatorial current, the sub-tropical waters flow mainly from the north-west—i.e., southwards from the southern margins of the North Pacific current. In the south Pacific, on the other hand, the sub-tropical currents, like those which branch off southwards from the whole southern margin of the south equatorial current, flow from north to south, although they are rarely due north-south currents, until they come into the regions of the westerlies. On the whole, particularly in mid-ocean, they are variable and very weak. The trade winds of the south Pacific are less constant than those which flow north of the equator.

The minor currents between south-east Australia and New Zealand which are exceptional to this general scheme in the sub-tropical waters of

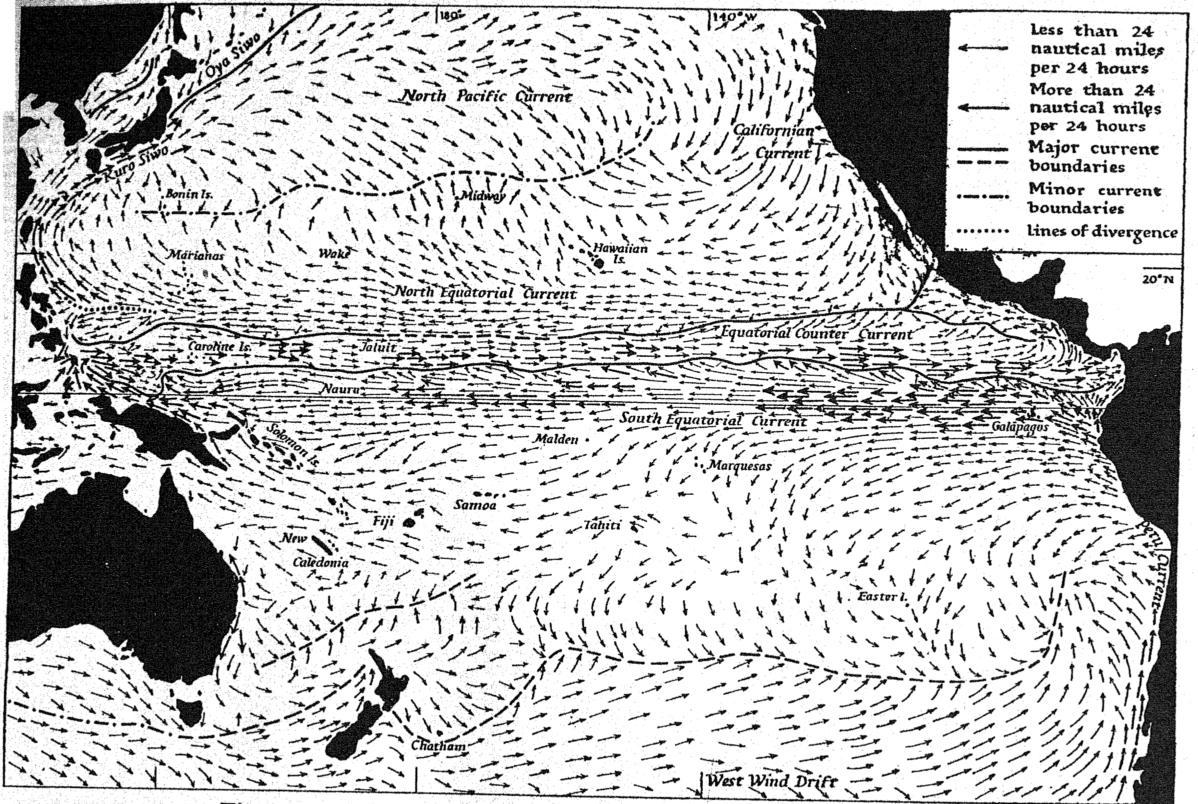

Fig. 120. Ocean circulation : northern summer (August to September)

In this and Fig. 121 the variability of the currents is indicated by the legnths of the arrows (the more variable, the shorter the arrow). Based on : (1) G. Schott, *Geographie des indischen und stillen Ozeans*, Tafel 29-30 (Hamburg, 1935) ; (2) G. Schott, 'Nachtrag zu dem Aufsatz die Grundlagen eine Weltkarte der Meersströmungen', *Annalen der Hydrographic und Maritimen Meteorologie* (Berlin, 1943).

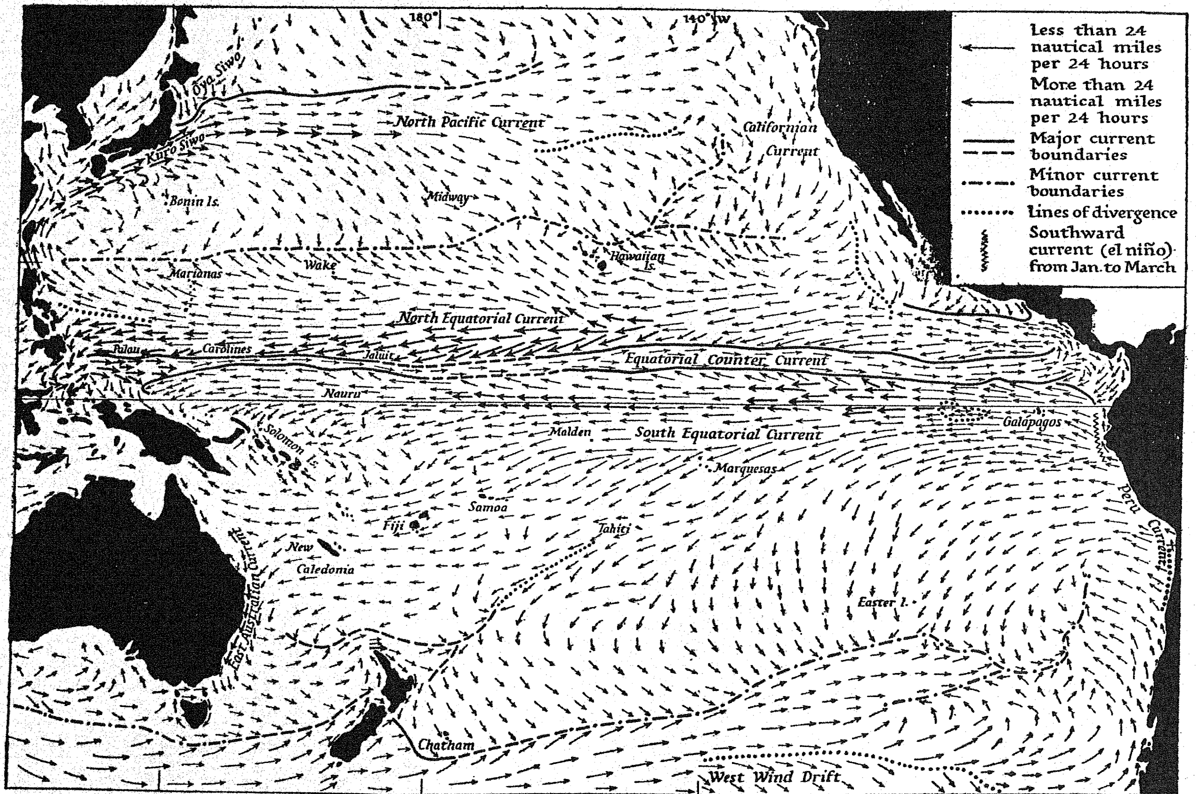

Fig. 121. Ocean circulation : northern winter (February to March)
In the area enclosed by the dotted line (west of the Galápagos group) there is usually an eastward current in March. Based on the same source as Fig. 120.

Island or group	General direction of current	Variations
Galápagos	E to W, normally	Very strong in northern summer. Marked changes may occur in Jan.-March—southward current in force
Juan Fernández	S to N	Variants of this component may occur
Easter	Variable	NE to SW in northern winter. Reversals may occur in northern summer
Pitcairn	E to W	Rate about 12 miles per day
Society islands	E to W, but not very regular among the islands	Occasionally reversed by winds with westerly component
Tuamotu archipelago Mangareva group	Subject to seasonal reversal	E to W under trades. W to E in October to March (in which season westerlies may occur)
Austral islands	NNW to SSE, most frequently	Variable, northerly component most common
Marquesas	E to W	Occasional reversals after westerly winds. Mainly within south equatorial current
Malden	E to W	32 to 56 miles per day (south equatorial current)
Hawaiian islands	E to W	Rather variable. Reversals fairly common
Christmas	E to W and SE to NW	37 miles per day maximum. Equatorial counter current may provide reversals
Phoenix	E to W	Mainly strong south equatorial current
Tokelau islands	E to W and fairly strong in northern winter	Otherwise variable
Cook islands	E to W	May be reversed by persistent winds with westerly component
Samoa	N coast of Upolu, SE to NW under trades; S of Upolu, W to E; Tutuila, NE to SW	Vary in force and direction with winds. May be SE to NW between Upolu and Tutuila
Tonga	E to W in northern winter; ESE to NNW in northern summer	Very slight currents in fine weather season. Variable in northern summer

Island or group	General direction of current	Variations
Fiji	E to W ; under trade or east wind influence	W–E when westerlies persist, usually in summer
Gilbert islands Ellice islands	E to W (south equatorial current) ; NE to SW in northern winter under trades	Variable (winds variable). Strong currents at most periods. Equatorial counter current may affect both groups
Kermadec islands ..	W to E or SW to NE from North Island, N.Z.	Kauri logs carried to shores of Kermadecs almost continuously
New Caledonia ..	(i) East coast, SE to NW, normally (Rossel current) ; (ii) West coast, variable (outside influence of New Holland current flowing from E to W off the south tip)	Weak currents felt only on outer margin of barrier reef. (i) N or NW wind produces counter current.
Solomon islands ..	Weak ; set with trades	Stronger currents develop in straits
New Guinea and Admiralty islands ..	NE coast, SE to NW; but W to E in February	Change with 'monsoons'. Liable to many changes under influence of winds
New Britain .. New Ireland.. Palau	Weak, vary with wind	In all groups strong currents develop in intervening straits
Caroline islands ..	E to W (north equatorial current)	Equatorial current may set W to E under 'monsoon' influence in east Carolines
Marshall islands ..	E to W north of 8°N	Reversals may occur with wind changes or with shift of counter equatorial current
Wake	ESE to WNW in northern summer; NNE to SSW possible in northern winter	Variable and slight
Guam	NE to SW under trades (also E to W)	Typhoons may shift current
Marianas	E to W (north equatorial current)	Strongest around and south of Saipan, decreases northward. Strong currents may arise because of addition of tidal water

the south Pacific have already been noted. The greater number of islands in the tropical Pacific lie south of the equator and are thus set among currents with a generally east to west or north-east to south-west trend.

The Table on pp. 544-5 gives the average directions and some variations in the courses of the currents which affect the chief island groups. Indications of speed are given only for the stronger currents.

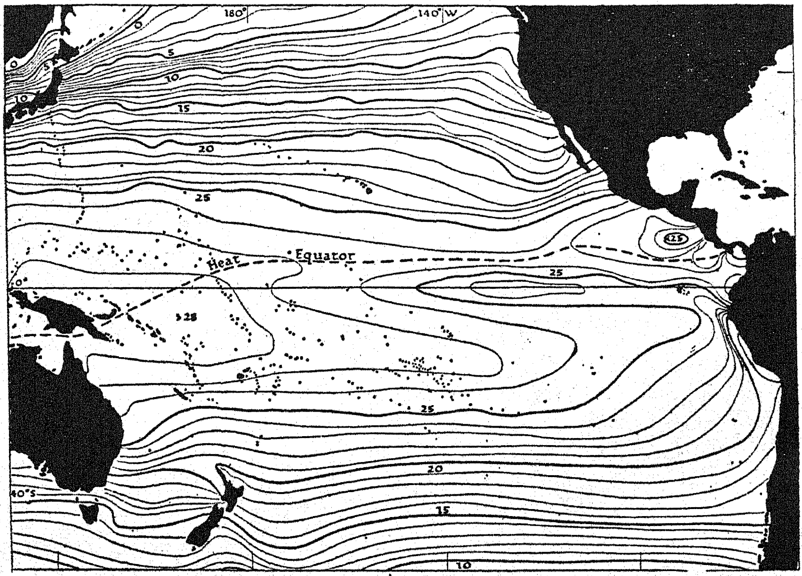

Fig. 122. Surface water temperature: February

In this and Fig. 123 the heat equator runs through the area with the highest temperatures. Temperatures are shown in degrees Centigrade. The two Figures are based on G. Schott, *Geographie des indischen und stillen Ozeans*, Tafel 20 and 22 (Hamburg, 1935).

Influence of Currents on Surface Water Temperatures

Figs. 122–3 show average temperatures of surface water for February and August. Comparison with Figs. 120–1 suggests that ocean currents are all-important in producing the conditions shown on the temperature charts. A striking feature is the vigorous westward progress of the relatively cool south equatorial current into the mid-Pacific area. The contribution of cold water from the Peru current is well brought out by the temperature charts and is seen in detail in the Galápagos group where considerable differences in the temperatures of surface water may exist between opposing coasts of the same island (vol. II, pp. 26–7). The water carried westward by the equatorial currents increases in warmth as it progresses, with the result that the warmest waters of the Pacific accumulate in equatorial latitudes of New Guinea and in a belt east and north of it. The northward and southward movement of the heat equator and area of maximum heat with that of the overhead sun and equatorial currents is very noticeable on

the charts. The counter equatorial current is fed at its initial western limit by these warm waters and, on reaching its eastern limit against the American coast, they provide distinct masses of warm water which differ markedly in temperature from the cooler waters which have passed southwards down the North American coast. This is seen on the map of surface temperatures for August. The role of the Kuro shio in increasing surface temperatures in this month is well seen in the Western Pacific.

It has been noted above that a complete circulation exists in tropical and sub-tropical waters in the north Pacific. During the northern summer the

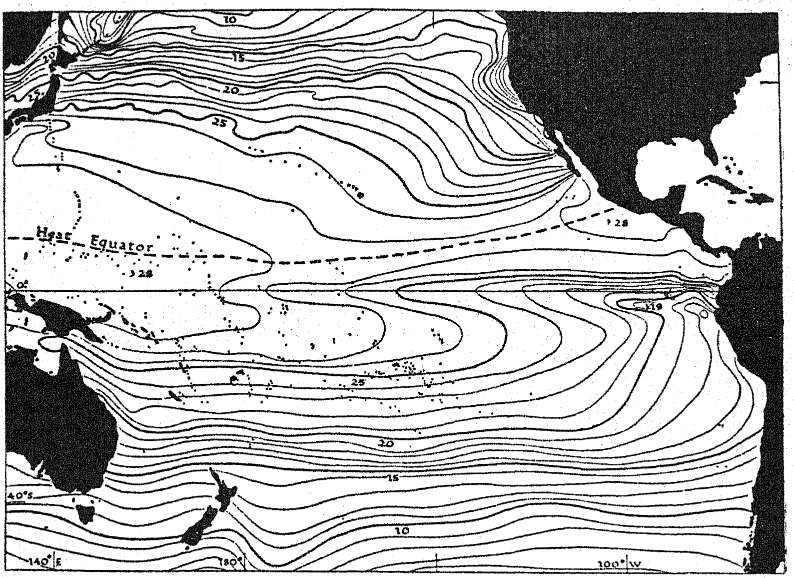

Fig. 123. Surface water temperature: August

For explanation and source see Fig. 122.

cooler water tends to be pushed northward by the warm Kuro shio and relatively warm North Pacific current, except off North America where temperature anomalies are shown on Fig. 123. During the northern winter there is a more even temperature gradient over the surface waters of the north Pacific. At all seasons in the south Pacific, the isotherms tend to correspond more closely to lines of latitude and to be more evenly graded. Exceptional conditions are produced by the Peru current in the extreme east, but elsewhere, in the absence of a southern counterpart of the Kuro shio, the temperature zones grade evenly from the east coast of Australia to the ocean east of Easter island. The temperature conditions reflect the continuous displacement southward of large masses of warm water which gradually cools in passing over the great stretches of ocean which intervene between equatorial and temperate latitudes. Apart from New Guinea, the Bismarck archipelago and the Solomons, the islands of the southern half of the Pacific lie in surface waters with a temperature of over 25°C. (77°F.) in their summer and over 20°C. (68°F.) in their winter.

A general account of Pacific Ocean currents and references to additional literature are given by G. Schott in *Geographie des Indischen und Stillen Ozeans*, pp. 161–71 (Hamburg, 1935). The variability of the currents of the south Pacific ocean is shown by means of tables and diagrams in the Marine Division of the Meteorological Office, *South Pacific Ocean Currents* (London, 1938). Such detailed information as is available for individual island groups will be found in: the Admiralty, *Pacific Islands Pilot*, vol. I (6th edition, London, 1933), vol. II (6th edition, London, 1932), vol. III (6th edition, London, 1931); *South America Pilot*, part III (3rd edition, London, 1941); and the U.S. Hydrographic Office, *Sailing Directions for the Pacific Islands*, vol. I: *Western Groups* (4th edition, Washington, 1938), vol. II: *Eastern Groups* (5th edition, Washington, 1940); *Sailing Directions for South America*, vol. III (4th edition, Washington, 1938).

Appendix II

SALINITY

Fig. 124 shows the varying salinity of the surface waters of the Pacific by means of *isohalines* which show the weight (in grams) of salts per kilogram of sea water. A representative value for the hydrosphere is 35 parts per

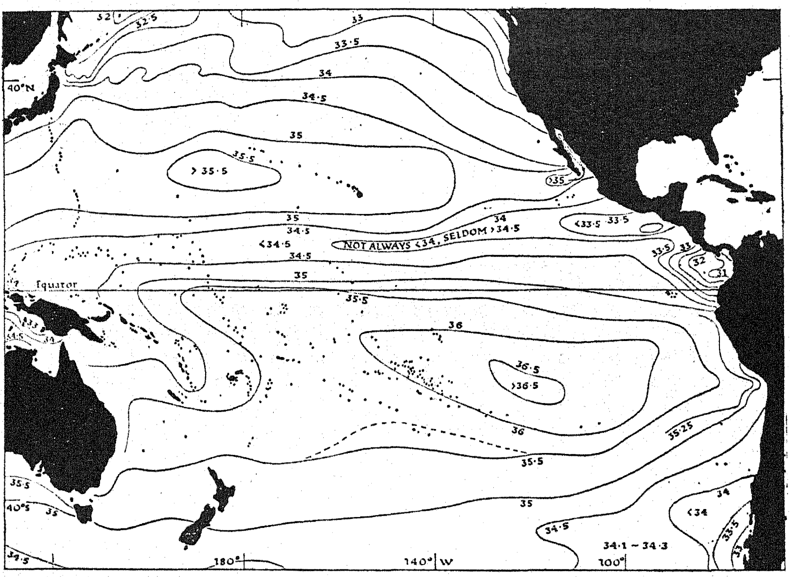

Fig. 124. Average surface water salinity

The co-salinity lines (isohalines) show the weight of salt in grams in parts per thousand by weight. In the regions affected by monsoons the salinity distribution is shown for the period of the northerly monsoon. Based on G. Schott, *Geographie des indischen und stillen Ozeans,* Tafel 27 (Hamburg, 1935).

thousand by weight. Several factors must be considered in connection with the salts content of a particular area of ocean. The total yearly rainfall, the river water (or in high latitudes glacier water) contributed by the surrounding lands, and the evaporation of marine surface water are all important. These factors are of general application. World position, relationship to currents, and to the wind belts which help to produce them, and connections with water circulation at greater depths, have each their regional significance. Thus Figs. 45–6 and 49 may profitably be compared with Fig. 124.

Broadly speaking, the isohalines of the Pacific ocean are spaced latitudinally. Fig. 124 shows some outstanding areas, viz., the roughly oval area of maximum salinity which stretches from the ocean west of the Tuamotu archipelago to that north and east of Easter island, and a secondary

maximum salinity area which lies north of the equator, west of the Hawaiian islands. The noteworthy areas of minimum salinity lie: in the north Pacific largely north of 40°N (the minimum, <31, is reached in Bering strait); west of the Central American coast and in a long latitudinal tongue reaching westwards from it; and off the coast of southern Chile. In the latter area again, the lowest salinity is attained along a coastal stretch which lies outside the area included on Fig. 124.

The factors responsible for these distributions appear to be firstly, remoteness from the more rapidly moving surface currents. Figs. 120–1 show a partial coincidence of the current boundaries with the isohalines which define regions of maximum salinity. Thus between about 30° and 20°N and about 15° and 25°S there are two ocean masses in which water circulation and intermixing is relatively slight, but which are exposed to strong heating from the tropical, and at certain seasons overhead, sun. Between the two lies a belt of less salt water which in a general sense coincides with the three vigorously circulating equatorial currents. The greater mass of surface water is here moving westwards and is increasing its temperature and salinity outwards from the Central American coast. The minimum figures of the Panama gulf may be explained in terms of the excessive rainfall of the seas off the isthmus (especially in the northern summer) and the off-shore winds which give rise to the upwelling, off the coast, of colder and less salt water from greater depths. Similar conditions apply off south Chile. On the western side of the Pacific, off northern New Guinea and south-eastwards from it, the seas are less salt than might be expected in a region of high temperatures. Here waters of low salinity move in relatively rapidly from the east, and the water circulation does not allow of the accumulation of stagnant masses of water on a large scale. The total yearly rainfall is nearer 150 than 100 in. over much of the area. Fig. 49 demonstrates this, and also a general similarity in the trend of isohyets and isohalines in the western part of the central Pacific. The less salt waters of this region are dispersed by the Kuro shio towards the Philippines and Japan, and by the east Australian current down the coast of that continent. The area of minimum salinity in the northern Pacific which pushes a tongue southward down the west coast of North America into the area included on Fig. 124 may be explained by the southward passage of the cool Californian current and by the water contributed by rivers. The water contributed by rain from the west American coastlands north of 40°N and south of 40° S is excessive and is not subjected to the same degree of loss by evaporation as in tropical areas of high rainfall.

Fig. 124 gives a generalized picture of surface water salinity in the Pacific. A detailed examination of individual island groups would reveal pockets of surface water in sheltered bays, behind headlands and in lagoons which could be remote from, and more salt than, the circulating waters. A large scale example of this feature is the Californian gulf. On the other hand, on lee shores where the surface water is being driven away from the land, less salt water may well up and provide a local area of low salinity.

Appendix III

TIDES IN THE PACIFIC

The Table on the following page shows the daily average levels of the tides at 21 stations. The information is given in this form to indicate in a general way the usual characteristics of the tide at these stations. The actual heights on a given day depend upon astronomical conditions; they may be predicted from the data given in the Admiralty *Tide Tables*. Details of tidal streams in relation to local controls are given in the Admiralty *Pacific Islands Pilot*, 3 vols. (6th edition, London, 1931–3), and the United States Hydrographic Office *Sailing Directions for the Pacific Islands*, 2 vols. (4th–5th edition, Washington, 1938, 1940).

Tides in the Pacific

Station	Position		Average height in ft.				Remarks*
			high water		low water		
	lat.	long.	higher	lower	higher	lower	
Pagan, Marianas	18°08′N	145°46′E	2·1	2·1	1·4	0·4	Tides are mainly semidiurnal but with considerable inequality in the heights of successive low waters
Apra, Guam	13°26′N	144°39′E	2·5	2·0	0·8	0·5	
Tomil harbour, Caroline Is.	6°18′N	137°29′E	4·8	4·5	2·5	1·1	
Truk, Caroline Is.	7°22′N	151°53′E	2·3	—	—	1·0	Tide mainly diurnal. When the moon is on the equator tides may be semidiurnal
Ponape harbour, Caroline Is.	6°59′N	158°13′E	3·6	2·6	1·5	1·4	Tides are mainly semidiurnal with a small inequality in the heights of successive high waters
Kwajalein, Marshall Is.	8°44′N	167°44′E	4·9	4·3	1·4	1·4	
Fanning I.	3°51′N	159°22′W	2·0	1·6	0·6	0·6	
Honolulu, Oahu	21°18′N	157°52′W	1·8	0·8	0·3	0·1	Tides are mainly semidiurnal but with considerable inequality in the heights of successive high waters
Finschhafen, New Guinea	6°33′S	147°52′E	2·9	—	—	1·5	Tides are practically always diurnal; occasionally inappreciably small semidiurnal tides may occur
New Britain	4°16′S	152°11′E	1·5	—	—	0·5	
Duchateau Is., Louisiade Arch.	11°17′S	152°22′E	3·9	2·6	2·1	1·3	Mixed semidiurnal and diurnal tides
Nususonga, New Georgia	8°25′S	157°14′E	1·9	—	—	0·5	Tides are always diurnal
Royalist harbour, Malaita	9°19′S	161°04′E	4·3	3·3	1·7	1·1	Tides are mainly semidiurnal but with inequality in the heights of successive high and low waters
Port Sandwich, New Hebrides	16°26′S	167°47′E	3·9	3·4	1·4	0·5	Tides are mainly semidiurnal but with appreciable inequality in the heights of successive low waters
Funafuti, Ellice Is.	8°31′S	179°12′E	5·6	5·0	1·6	1·4	In the south Pacific, between the longitudes of Fiji and Mangareva, tides are almost entirely semidiurnal. The occurrence of spring tides varies from about one day after full or new moon in Fiji to about two days before full or new moon in Mangareva
Rotuma	12°30′S	177°05′E	4·9	4·3	1·6	1·2	
Suva, Fiji	18°09′S	178°26′E	5·0	4·6	1·4	0·9	
Nomuka, Tonga	20°16′S	174°48′W	5·0	4·6	1·5	1·3	
Apia, Samoa	13°49′S	171°46′W	3·0	2·6	0·5	0·3	
Papeari harbour, Tahiti	17°45′S	149°22′W	0·9	0·9	0·4	0·3	
Rikitea, Mangareva	23°07′S	134°57′W	2·2	2·2	0·4	0·4	

*(i) Semidiurnal tides have two high and two low waters in each lunar day and have their maximum range at about the time of full or new moon, particularly near the equinoxes.

(ii) Diurnal tides have one high and one low water in each lunar day and have their maximum range at about the time that the moon has its greatest declination, particularly near the solstices.

(iii) With mixed types, semidiurnal or diurnal tides will predominate according to the moon's phase or declination respectively and according to the relative magnitude of the semidiurnal and diurnal constituents.

Appendix IV

TIME CHART

The accompanying map (Fig. 125) shows the time zones of the Pacific islands region and the International Date Line. The Date Line follows the meridian of 180°, except where it has been modified to simplify relations between regions with strong common interests. Thus, Tonga, though well to the east of the meridian of 180°, has elected to keep the same date as Fiji, Australia and New Zealand, with which it is most closely connected. The standard zones are indicated on the upper and lower margins of the map. Times observed in individual island groups may not be identical with those of the zone or zones in which they lie and are therefore shown by clocks. These clocks and those on the southern margin show Pacific time when it is midnight at Greenwich. Some doubt exists as to whether Easter island and Galápagos keep the standard time of the zones in which they lie. Chilean standard time was recently altered to Greenwich time + 4 hours, but it is not known whether the Chilean possession of Juan Fernández has complied with this change.

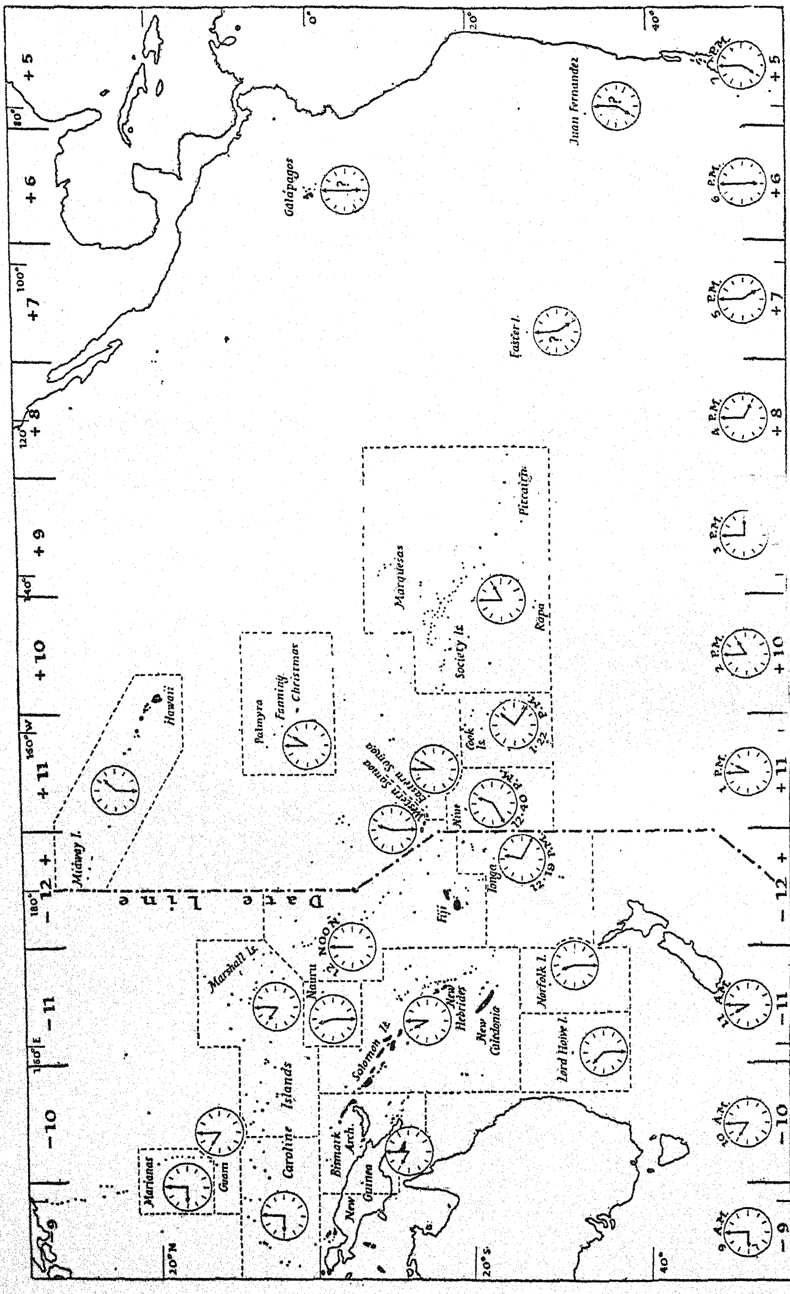

Fig. 125. Time chart
The clocks show Pacific time when it is midnight at Greenwich.

Appendix V

HINTS ON THE PRESERVATION OF HEALTH IN THE PACIFIC ISLANDS

The following notes are intended for the assistance of Europeans in the Pacific islands who may be out of reach of medical assistance.

The list of diseases given in Chapter VII appears formidable. But it should be remembered that the list refers to the native population. Europeans can avoid most diseases by taking simple precautions.

A point to remember is that at home the private citizen hardly needs to take steps to preserve his health. The community sees to it that the water supply is fit to drink, the food up to standard and so forth. But in the islands the individual must know how to avoid needless disease, and may have to take active steps to keep himself and those dependent on him in good health. The following simple points are important.

1. Many diseases are liable to be picked up from the native inhabitant. If there is any choice, live as far as possible from villages and labour corps.

2. Malaria is conveyed from man to man only by certain sorts of mosquito (*Anopheles*). The mosquito must first bite a man whose blood contains the germ of malaria; the mosquito incubates the germ for a week, and is then prepared to inoculate it into others if it bites them. All mosquitoes breed in water; unfortunately many can fly a long way, seeking blood. Malaria is absent from islands east of longitude 170° E.

(a) To avoid malaria, camp as far as possible from swamps, rivers, and irrigated land; ½ mile will give considerable protection. Camp away from villages because the *Anopheles* often picks up the germ from the native.

(b) Sleep under a mosquito net carefully used and tucked in and kept in good repair. If sleeping on the ground, tuck the edge of the net under a ground sheet.

(c) Avoid being needlessly bitten: no bare legs or arms at or after sundown.

(d) If possible kill mosquitoes in tents, etc., with fly spray.

(e) Official action is often taken to destroy the mosquito larvae in water, by oiling, using poisonous dusts, draining, etc. This work is very important to health. Assist it if necessary.

(f) A dose of 5 grains of quinine taken each evening has some action in preventing attacks of malaria.

(g) If there is no medical officer, treat a case of fever by making the patient lie down, giving 10 grains of quinine and a dose of salts.

3. In warm climates, intestinal ailments are very common in Europeans. They may take the form of gripes and looseness; or a frequent diarrhœa; or dysentery (which means the passage of blood and mucus, often with severe griping pains); or more serious things such as typhoid fever.

All these troubles are due to germs, which come from some other person's excrement and have been swallowed by the sufferer. They may be swallowed in water, or milk, or uncooked food (raw fruit, salads, etc.). They are carried about in a variety of ways: for instance, the cook may soil his hands in the latrine and then infect the food he is serving; flies may feed on a deposit of human faeces, and then on a lump of sugar or piece of bread, or something which is to be eaten without further cooking; someone eases himself by the stream, and fouls the water; and so forth.

These diseases are avoided :

(a) by chlorinating or boiling all water (however clean it looks) before drinking it or cleaning teeth in it ;
(b) by never drinking unboiled fresh milk, or locally prepared mineral waters ;
(c) by not eating lettuces, etc. (which cannot be cleaned by reason of the folds) ;
(d) by endeavouring to make cooks and those who serve food wash their hands ;
(e) by providing facilities for hand washing in all latrines ;
(f) by insisting on the cleanliness of cookhouses, and burning of odd scraps of food ;
(g) by keeping latrines clean, and as far as possible fly-proof ;
(h) by insisting that latrines, and no other spots, are used (this applies particularly to undisciplined local levies, labour corps, etc.) ;
(i) by keeping one's body warm at night ;
(j) by being inoculated against typhoid and paratyphoid.

In the absence of a medical officer one treats minor intestinal troubles by rest (i.e., lying down, taking only water for a day or so), warmth and a dose of salts.

4. Lice may appear in garments, or in some parts fleas may carry disease.

5. If it is windy and dusty, use an eye-screen. If suffering from an inflamed eye and there is no medical officer, boil some water, let it cool, and fill a mug with it : open and shut the eye under water repeatedly. If a piece of grit can be seen on the eyeball or inside the lid remove it with a corner of a handkerchief. A drop of castor oil will often soothe an eye inflamed by dust.

6. Whenever possible wash all over, not only because one gets so dirty in a hot and dusty place, but also because soreness may easily develop, particularly between the toes and in the crutch : if these parts become inflamed it is not easy to cure them. Do not walk about barefoot.

7. Be vaccinated (against smallpox) and inoculated (against typhoid and tetanus).

8. If going on an expedition, obtain a few simple medicines and dressings from a medical officer, and get some instruction in their use.

9. Venereal diseases are more common than at home, and one particularly nasty tropical one exists. Take no risks.

10. To prevent septic sores and ulcers avoid minor injuries ; if they occur treat at once with iodine ; maintain the general health with local fruit wherever possible.

11. Snake bite is an emergency which may have to be dealt with in New Guinea. If a member of the party has been bitten by a viper or similar snake, he will get a great deal of swelling, pain and blackening of the skin. Make him as comfortable as possible, give him fluids and send for a doctor. Do not make matters worse by the use of razor blades, tourniquets, red-hot pennies, etc. All these may result in the bite becoming septic, and more serious.

Similarly after scorpion stings, rest the injured part, but do not make slits in it.

Appendix VI

MILITARY OPERATIONS IN THE PACIFIC, 1941–1944

Before the entry of Japan into the war, hostilities in the Pacific were confined to the depredations of German commerce raiders. Apart from shipping losses, they did some damage in December 1940 by shelling the phosphate loading facilities at Nauru.

Japan entered the war on 7 December 1941 and attacked without warning the Hawaiian islands, the Philippines, and Guam, Wake, and Midway islands. Advancing from bases in the Caroline and Marshall islands, Japanese forces penetrated the chain of islands from New Guinea to the Solomons, which stood between them and Australia. Another advance was made into the Gilbert islands to the east, thus menacing the route taken by supplies and reinforcements from America to Australia and New Zealand. By March 1942, when the Philippines, the Netherlands East Indies, British North Borneo, Sarawak and Portuguese Timor had been lost, General Douglas MacArthur was appointed Supreme Commander of all Allied forces in the south-west Pacific, with headquarters in Australia. The first necessity was to secure the supply-lines from America. On 25 April, New Zealand, with Fiji and the other islands for the defence of which New Zealand was responsible, were placed under American naval command (Admiral W. F. Halsey, U.S.N.) with headquarters in New Zealand. Two days later it was announced that American troops had landed in New Caledonia. Later, the presence of American army air and ground forces was announced in Fiji and the New Hebrides.

The naval battles of the Coral sea (6–11 May) and Midway island (7–8 June) were the first effective checks to the Japanese advance. In both of these, Japanese fleets were severely damaged by air attack. As a result, the Allied ground forces were able to begin a counter-offensive. Spreading northwards, they met the southward-advancing Japanese in a surprise landing by American marines on Guadalcanal and Tulagi on 7–8 August. The Japanese resisted strongly and at the same time extended their hold on the Gilbert islands. Another decisive clash occurred in New Guinea with the defeat of the Japanese at Milne bay. Then the Japanese advancing from Gona over the Owen Stanley mountains were finally thrown back in October by Australian forces 50 miles from Port Moresby.

These operations marked the extreme extent of the Japanese advance. Thenceforth the counter-offensive of the Australians and Americans in New Guinea and of Americans and New Zealanders in the Solomons proceeded steadily. Both these areas have now (December 1944) been cleared of the enemy except for a few large pockets of Japanese who are left cut off from their supplies and by-passed in the course of the Allied advance. These large pockets of Japanese, though dwindling in strength, still form a considerable element of enemy hostility which will have eventually to be eliminated. To the north and east of New Guinea, powerful American naval and ground forces have recaptured the Gilbert islands and occupied key positions throughout the Carolines, Marshalls and Marianas. In the course of this advance, several of the major Japanese bases, including Truk, have been subjected to heavy naval and air bombardment and then by-passed. The advance has since proceeded to the Philippines, where Leyte has been recaptured and large forces have been landed on Luzon.

The following Table gives some of the major military events in the Pacific since the entry of Japan into the war :

Table of Military Events, December 1941–September 1944

December 1941

7 Japanese attacked Pearl harbour, Guam, Wake and Midway.
9 Japanese attacked northern Gilbert islands (Butaritari, Marakei, Abaiang) ; Nauru and Ocean islands bombed.
10 Tarawa (Gilbert islands) raided by Japanese.
17 Australian and Dutch forces entered Timor.
24 Japanese occupied Wake island.
25 Second Japanese raid on Tarawa.

January 1942

20–21 Japanese launched heavy air attacks on main settlements in the Mandated Territory of New Guinea.
22 Tulagi bombed by Japanese.
23 Japanese occupied Rabaul and landed at places in the northern Solomons, including Kieta.

February 1942

2 United States naval forces attacked Japanese-occupied Gilbert islands.
15 Singapore capitulated.
18 Australian troops arrived in Java.
19 Australian troops resisted Japanese landing in Timor.
27 Japanese landed in Java.

March 1942

6 Japanese occupied Batavia.
7 Japanese landed at Lae and Salamaua, New Guinea.
10 Japanese landed at Finschhafen, New Guinea.
19 General MacArthur appointed Supreme Commander of all Allied forces in the south-west Pacific.

April 1942

7 Japanese occupied Faisi, Solomon islands.
8 Japanese occupied Lorengau, Admiralty islands.

May 1942

4 Japanese occupied Tulagi as naval and seaplane base.
6 Japanese occupation of the Philippines completed with the fall of Corregidor.
6–11 Battle of Coral sea.

June 1942

7–8 Battle of Midway island ; Japanese fleet heavily damaged by air attack.

July 1942

21 Japanese landed at Gona mission, on the north coast of Papua.
23 First contact between Australians and Japanese in Papua at Awala.

August 1942

7 U.S. forces landed on Guadalcanal.
8 U.S. forces captured Tulagi and adjacent islands.
9 Naval action by night off Savo island.
16 Australian troops withdrew from Kokoda, Papua.
25 Japanese landed at Milne bay, Papua ; landing opposed by Australians.

September 1942

5 Japanese withdrew by sea from Milne bay, having suffered their first decisive defeat on land in the south-west Pacific.
8 Japanese advanced from Kokoda.
14 Japanese crossed the Owen Stanley range, Papua.

17 Japanese counter-attacked on Guadalcanal with infantry, aircraft and warships.
28 Australian and U.S. forces captured cape Endaiadere, Papua.
21 Australians captured Komiatum ridge, New Guinea.

October 1942
1 Australian forces stemmed the Japanese advance on Port Moresby; Japanese forced to retreat across the Owen Stanley range.
26 Naval battle of Santa Cruz.

November 1942
2 Allies captured Kokoda after advance over the Owen Stanley range.
9 Australian forces recaptured Gorari, Papua.
11 Australians captured Oivi, Papua.
13 Australians captured Wairopi, Papua.
25 Australians reached Gona, Papua.

December 1942
9 Gona captured by Australian forces.
15 Destruction by air and naval attack of Japanese convoy of reinforcements for the Solomons.
28 Australian and American forces captured cape Endaiadere, Papua.

January 1943
2 Allies occupied Buna, Papua.
14 Australian and American forces took Sananada, Papua.
20 Australians defeated Japanese attack on Wau, New Guinea.
24 All land fighting in Papua ceased with the fall of the last Japanese strong points near Buna.

February 1943
3 Australian forces at Wau counter-attacked and began the drive to Salamaua.
10 Japanese resistance on Guadalcanal ended.

March 1943
4 Allied aircraft destroyed Japanese convoy off New Britain.
16 Japanese cleared from Mubo gardens, New Guinea.

June 1943
30 U.S. forces landed on Rendova, Solomon islands.

July 1943
2 U.S. forces landed on Kiriwina and Murua islands, and at Nassau bay, near Salamaua, New Guinea.
12 U.S. forces closed in on Munda airfield, New Georgia.

August 1943
7 Munda airfield occupied.

September 1943
4 Australian forces landed on shore of Huon gulf and began drives to Lae and Finschhafen.
5 U.S. and Australian airborne forces seized Nadzab, New Guinea.
7 U.S. and Australian airborne troops dropped over the Markham valley, New Guinea.
11 Salamaua recaptured by Australians.
16 Lae recaptured by Australians.
22 Australian troops landed at Finschhafen.

October 1943
2 Australians took Finschhafen.
4 Australians captured Dumpu in the Ramu valley, New Guinea.
8 Strong U.S. naval attack on Wake island.
12 Very heavy Allied air raid on Rabaul.
29 U.S. and New Zealand forces landed on Mono, Solomon islands.

November 1943
1 U.S. commandos and airborne troops landed on Choiseul.
3 U.S. troops landed at Empress Augusta bay, Bougainville.
16 U.S. naval aircraft bombed air bases in Gilberts and Marshalls.
21–26 U.S. marines recaptured the Gilbert islands.
25 Australian forces drove the Japanese from the Sattelberg heights, New Guinea.

December 1943
8 Strong forces of U.S. carrier-based aircraft attacked bases in the Marshalls. Australian forces captured Wareo, New Guinea.
17 U.S. troops landed at Arawe, New Britain.

January 1944
4 U.S. troops landed at Saidor, New Guinea.
23 Australian forces captured Shaggy ridge, New Guinea.

February 1944
1 U.S. forces began invasion of Marshalls after heavy sea and air bombardment.
10 Australian and U.S. forces linked up east of Saidor, New Guinea.
19 Truk attacked by large U.S. naval force.
25 Saipan and Tinian similarly attacked.

March 1944
1 U.S. forces made a surprise landing on Admiralty islands.

April 1944
12 Announcement that most of New Britain was in Allied hands, the Japanese having withdrawn to the Gazelle peninsula.
13 Australian forces captured Bogadjim, New Guinea.
24 Australians took Madang, New Guinea.
26 Australians took Alexishafen, New Guinea.

May 1944
29 U.S. troops landed on Biak island (Schouten group).

June 1944
10 U.S. carrier-based aircraft raided Saipan, Tinian and Guam.
15 Reported that U.S. forces had landed on Saipan and Tinian.

July 1944
5 Manam island, New Guinea, captured by U.S. troops.
10 Japanese resistance on Saipan ended.
20 U.S. marines and assault troops landed on Guam.
23 U.S. troops landed on Tinian.

August 1944
9 Guam recaptured.

September 1944
1 Heavy U.S. air attacks on islands in the Philippines, Bonins, Marianas, Marshalls and Carolines.
3 Similar attacks on Wake, Bonins, Marianas, Carolines and Nauru.
15 U.S. troops land on Peleliu (Palau group).
17 Announced that U.S. troops have landed on Angaur.

CONVERSION TABLES

METRIC AND BRITISH UNITS

It is customary to think of the 'metre' and the 'yard' as representing unalterable units of length. This is not so. The metre was originally intended to be the 10,000,000th part of the earth's meridional quadrant. But the accurate determination of this length proved to be extremely difficult—partly for technical reasons, and partly because of different conceptions of the 'figure of the earth'. In view of these difficulties it became necessary to define the length of the metre in terms of suitable metal bars measured under specified conditions of temperature, pressure, humidity, etc. Similar standard bars were also used to define the length of other units such as the yard. As all these metallic standards are subject to change, conversion tables differ according to the date of comparison between different bars. The tables that follow are based on the comparison between the yard and the metre made in 1895. This made 1 metre equivalent to 39·370113 in.

Metric System. List of Prefixes

Deca means ten times.	Deci means a tenth part of.
Hecto means a hundred times.	Centi means a hundredth part of.
Kilo means a thousand times.	Milli means a thousandth part of.

In abbreviations the Decametre, etc., is Dm., and the decimetre, etc., dm.

Note on 'Nautical', 'Geographical' and 'Statute' Miles

A British 'nautical mile' is the length of the minute of the meridian at any given latitude, and is therefore a variable unit. It is given in feet for Clarke's 1880 spheroid by the formula

$$60771{\cdot}1 - 30{\cdot}7 \cos 2\,\text{Lat.}$$

This is the sea mile of the scale of latitude and distance of the Admiralty Charts. From the above formula it will be found to vary from 6,046·4 ft. at the equator to 6,107·8 ft. at the poles, being 6,077·1 ft. at latitude 45°.

The so-called 'international nautical mile' of 1,852 m. or 6,076 ft. is the length of the minute of the meridian at latitude 45° on the international spheroid. This corresponds to the 6,077 ft. for Clarke's spheroid.

A 'geographical mile' is a fixed unit, being defined by some as the length of a minute of the equator and by others as that of the minute of the meridian at latitude 45°. According to the former definition its value on Clarke's spheroid is 6,087 ft. and according to the latter 6,077 ft. The round figure 6,080 is usually adopted for the purposes of ordinary navigation.

The British 'statute mile' measures 5,280 ft.

LIST OF CONVERSION TABLES

Table 1. *Length*

Nautical mile	Statute mile	Kilometre	Metre	Yard	Foot	Inch	Centimetre
1	1·152	1·853	1853	2027	6080*	72,960	185,300
0·8684	*1*	1·60934	1609·34	1760	5280	63,360	160,934
0·5396	0·621372	*1*	1000	1093·61	3280·84	39,370·1	100,000
0·0005396	0·0006214	0·001	*1*	1·09361	3·28084	39·3701	100
0·0004934	0·0005682	0·0009144	0·914399	*1*	3	36	91·4399
0·0001645	0·0001894	0·0003048	0·3048	0·33333	*1*	12	30·48
0·0000137	0·0000158	0·0000254	0·0254	0·02778	0·083333	*1*	2·54
0·0000054	0·0000062	0·00001	0·01	0·0109361	0·032808	0·393701	*1*

* This is the customary British practice, and not the ' international nautical mile ', which Great Britain has not adopted.

Table 2. *Area*

Square mile	Square kilometre	Hectare	Acre	Square metre	Square yard
1	2·58998	258·998	640	2,589,980	3,097,600
0·386103	*1*	100	247·106	1,000,000	1,195,990
0·003861	0·01	*1*	2·47106	10,000	11,959·9
0·0015625	0·0040469	0·404685	*1*	4046·85	4840
0·00000039	0·000001	0·0001	0·000247	*1*	1·19599
0·00000032	0·00000084	0·0000836	0·000207	0·836126	*1*

Table 3. *Yield per Unit Area*

Tons per acre	Metric tons per hectare	Quintals per hectare
1	2·51071	25·1071
0·398294	*1*	10
0·0398294	0·1	*1*

Table 4. *Volume and Capacity*

Kilolitre	Cubic metre	Cubic yard	Bushel	Cubic feet	Imp. gall.	Litre	Pint
1	1·000027	1·30799	27·4969	35·3157	219·976	1000	1759·8
0·999973	*1*	1·30795	27·4962	35·3148	219·970	999·973	1759·75
0·764532	0·764553	*1*	21·0223	27	168·178	764·532	1345·43
0·0363677	0·0363687	0·0475685	*1*	1·28435	8	36·3677	64
0·028316	0·028317	0·037037	0·778602	*1*	6·22882	28·3160	49·8306
0·0045460	0·0045608	0·0059461	0·125	0·160544	*1*	4·54596	8
0·001	0·001	0·001308	0·027497	0·035316	0·219976	*1*	1·75980
0·0005682	0·0005683	0·0007433	0·015625	0·020068	0·125	0·56824	*1*

Table 5. *Weight*

Ton	Metric ton or millier	Quintal	Kilogram	Pound
1	1·01605	10·1605	1016·05	2240
0·984207	*1*	10	1000	2204·62
0·0984207	0·1	*1*	100	220·462
0·0009842	0·001	0·01	*1*	2·20462
0·0004464	0·0004536	0·004536	0·453592	*1*

Table 6. *Temperature: Equivalents of Fahrenheit and Centigrade Scales*

°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
100	37·7	79·25	26·25	58	14·4	37·4	3	17	—8·3	—4	—20
99·5	37·5	79	26·1	57·2	14	37	2·7	16·25	—8·75	—5	—20·5
99	37·2	78·8	26	57	13·8	36·5	2·5	16	—8·8	—5·8	—21
98·6	37	78	25·5	56·75	13·75	36	2·2	15·8	—9	—6	—21·1
98	36·6	77	25	56	13·3	35·6	2	15	—9·4	—6·25	—21·25
97·25	36·25	76	24·4	55·4	13	35	1·6	14	—10	—7	—21·6
97	36·1	75·2	24	55	12·7	34·25	1·25	13	—10·5	—7·6	—22
96·8	36	75	23·8	54·5	12·5	34	1·1	12·2	—11	—8	—22·2
96	35·5	74·75	23·75	54	12·2	33·8	1	12	—11·1	—8·5	—22·5
95	35	74	23·3	53·6	12	33	0·5	11·75	—11·25	—9	—22·7
94	34·4	73·4	23	53	11·6	32	0	11	—11·6	—9·4	—23
93·2	34	73	22·7	52·25	11·25	31	—0·5	10·4	—12	—10	—23·3
93	33·8	72·5	22·5	52	11·1	30·2	—1	10	—12·2	—10·75	—23·75
92·75	33·75	72	22·2	51·8	11	30	—1·1	9·5	—12·5	—11	—23·8
92	33·3	71·6	22	51	10·5	29·75	—1·25	9	—12·7	—11·2	—24
91·4	33	71	21·6	50	10	29	—1·6	8·6	—13	—12	—24·4
91	32·7	70·25	21·25	49	9·4	28·4	—2	8	—13·3	—13	—25
90·5	32·5	70	21·1	48·2	9	28	—2·2	7·25	—13·75	—14	—25·5
90	32·2	69·8	21	48	8·8	27·5	—2·5	7	—13·8	—14·8	—26
89·6	32	69	20·5	47·75	8·75	27	—2·7	6·8	—14	—15	—26·1
89	31·6	68	20	47	8·3	26·6	—3	6	—14·4	—15·25	—26·25
88·25	31·25	67	19·4	46·4	8	26	—3·3	5	—15	—16	—26·6
88	31·1	66·2	19	46	7·7	25·25	—3·75	4	—15·5	—16·6	—27
87·8	31	66	18·8	45·5	7·5	25	—3·8	3·2	—16	—17	—27·2
87	30·5	65·75	18·75	45	7·2	24·8	—4	3	—16·1	—17·5	—27·5
86	30	65	18·3	44·6	7	24	—4·4	2·75	—16·25	—18	—27·7
85	29·4	64·4	18	44	6·6	23	—5	2	—16·6	—18·4	—28
84·2	29	64	17·7	43·25	6·25	22	—5·5	1·4	—17	—19	—28·3
84	28·8	63·5	17·5	43	6·1	21·2	—6	1	—17·2	—19·75	—28·75
83·75	28·75	63	17·2	42·8	6	21	—6·1	0·5	—17·5	—20	—28·8
83	28·3	62·6	17	42	5·5	20·75	—6·25	0	—17·7	—20·2	—29
82·4	28	62	16·6	41	5	20	—6·6	—0·4	—18	—21	—29·4
82	27·7	61·25	16·25	40	4·4	19·4	—7	—1	—18·3	—22	—30
81·5	27·5	61	16·1	39·2	4	19	—7·2	—1·75	—18·75	—23	—30·5
81	27·2	60·8	16	39	3·8	18·5	—7·5	—2	—18·8	—23·8	—31
80·6	27	60	15·5	38·75	3·75	18	—7·7	—2·2	—19	—24	—31·1
80	26·6	59	15	38	3·3	17·6	—8	—3	—19·4	—24·25	—31·25

Table 7.

Pressure : Equivalents of Millibars, Millimetres of Mercury and Inches of Mercury at 32° F. in Latitude 45°

Mercury in.	Milli-bars	Mercury mm.	Mercury in.	Milli-bars	Mercury mm.	Mercury in.	Milli-bars	Mercury mm.	Mercury in.	Milli-bars	Mercury mm.	Mercury in.	Milli-bars	Mercury mm.
27·02	915	686·3	27·82	942	706·6	28·62	969	726·8	29·41	996	747·1	30·21	1,023	767·3
27·05	916	687·1	27·85	943	707·3	28·65	970	727·6	29·44	997	747·8	30·24	1,024	768·1
27·08	917	687·8	27·88	944	708·1	28·67	971	728·3	29·47	998	748·6	30·27	1,025	768·8
27·11	918	688·6	27·91	945	708·8	28·70	972	729·1	29·50	999	749·3	30·30	1,026	769·6
27·14	919	689·3	27·94	946	709·6	28·73	973	729·8	29·53	1,000	750·1	30·33	1,027	770·3
27·17	920	690·1	27·97	947	710·3	28·76	974	730·6	29·56	1,001	750·8	30·36	1,028	771·1
27·20	921	690·8	28·00	948	711·1	28·79	975	731·3	29·59	1,002	751·6	30·39	1,029	771·8
27·23	922	691·6	28·03	949	711·8	28·82	976	732·1	29·62	1,003	752·3	30·42	1,030	772·6
27·26	923	692·3	28·05	950	712·6	28·85	977	732·8	29·65	1,004	753·1	30·45	1,031	773·3
27·29	924	693·1	28·08	951	713·3	28·88	978	733·6	29·68	1,005	753·8	30·48	1,032	774·1
27·32	925	693·8	28·11	952	714·1	28·91	979	734·3	29·71	1,006	754·6	30·51	1,033	774·8
27·35	926	694·6	28·14	953	714·8	28·94	980	735·1	29·74	1,007	755·3	30·53	1,034	775·6
27·38	927	695·3	28·17	954	715·6	28·97	981	735·8	29·77	1,008	756·1	30·56	1,045	776·3
27·41	928	696·1	28·20	955	716·3	29·00	982	736·6	29·80	1,009	756·8	30·59	1,036	777·1
27·44	929	696·8	28·23	956	717·1	29·03	983	737·3	29·83	1,010	757·6	30·62	1,037	777·8
27·46	930	697·6	28·26	957	717·8	29·06	984	738·1	29·86	1,011	758·3	30·65	1,038	778·6
27·49	931	698·3	28·29	958	718·6	29·09	985	738·8	29·89	1,012	759·1	30·68	1,039	779·3
27·52	932	699·1	28·32	959	719·3	29·12	986	739·6	29·92	1,013	759·8	30·71	1,040	780·1
27·55	933	699·8	28·35	960	720·1	29·15	987	740·3	29·94	1,014	760·6	30·74	1,041	780·8
27·58	934	700·6	28·38	961	720·8	29·18	988	741·1	29·97	1,015	761·3	30·77	1,042	781·6
27·61	935	701·3	28·41	962	721·6	29·21	989	741·8	30·00	1,016	762·1	30·80	1,043	782·3
27·64	936	702·1	28·44	963	722·3	29·24	990	742·6	30·03	1,017	762·8	30·83	1,044	783·1
27·67	937	702·8	28·47	964	723·1	29·26	991	743·3	30·06	1,018	763·6	30·86	1,045	783·8
27·70	938	703·6	28·50	965	723·8	29·29	992	744·1	30·09	1,019	764·3	30·89	1,046	784·6
27·73	939	704·3	28·53	966	724·6	29·32	933	744·8	30·12	1,020	765·1	30·92	1,047	785·3
27·76	940	705·1	28·56	967	725·3	29·35	994	745·6	30·15	1,021	765·8	30·95	1,048	786·1
27·79	941	705·8	28·59	968	726·1	29·38	995	746·3	30·18	1,022	766·6	30·98	1,049	786·8

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